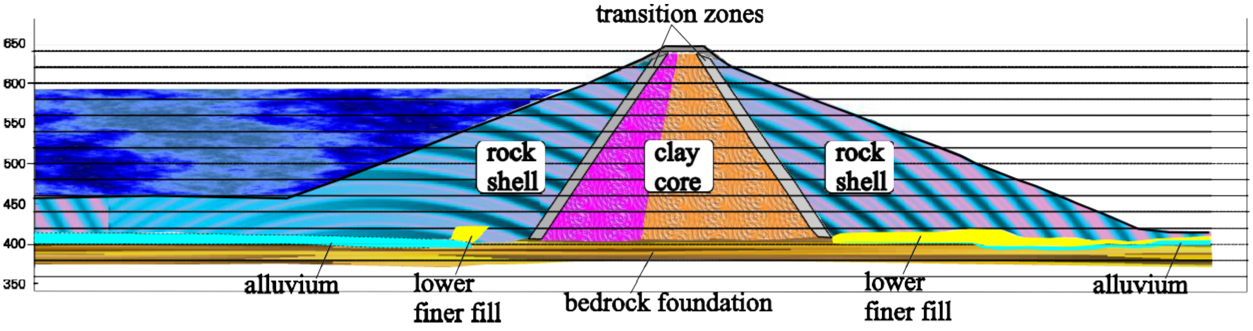
January 2013

2012 SURVEILLANCE REPORT
December 2011 through December 2012
LEROY ANDERSON DAM NO. 72-9
Santa Clara County



Santa Clara Valley Water District

Santa Clara Valley
Water District

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AN EQUAL OPPORTUNITY EMPLOYER

January 23, 2013

Mr. David A. Gutierrez, Chief
Division of Safety of Dams
Department of Water Resources
1416 Ninth Street
P.O. Box 942836
Sacramento, CA 94236-0001

Subject: Leroy Anderson Dam, No. 72-9, Santa Clara County
December 2011 through December 2012
2012 Surveillance Report

Dear Mr. Gutierrez:

Please find enclosed two copies of our 2012 surveillance report for Leroy Anderson Dam covering the period from December 2011 to December 2012.

Our review of the surveillance data and our periodic safety inspections indicate that Anderson Dam and appurtenant structures appear to show normal response to their environment, aging process, and external events. There were no major incidents or changes at the dam during 2012. All collected instrument data are well below established upper Action Levels. In addition, all collected instrument data are well above established lower Action Levels. Consequently, during the period of this report there were no surveillance instrumentation alarm conditions.

The Santa Clara Valley Water District will continue with the current monitoring program and safety inspections and will keep DSOD informed of any significant changes pertaining to the surveillance or performance of Anderson Dam. During the current reporting period, there were no new activities at the site that would impact monitoring of this facility.

Please contact me at (408) 630-2736, if you have any questions.

Sincerely,

James [illegible]. Fiedler
Chief Operating Officer
Water Utilities Enterprise

Enclosures
cc/enc: F. Maitski, T. Dougherty, H. Desai, **M.** Mooers, B. Baker, S. Wu, J. Nelson, library **(4)**
cc: R. Jacobs, D. Hook, L. Lopez
jn:mf
0116a-l.docx

The mission of the Santa Clara Valley Water District is a healthy, safe and enhanced quality of living in Santa Clara County through watershed stewardship and comprehensive management of water resources in a practical, cost-effective and environmentally sensitive manner.

2012 SURVEILLANCE REPORT
December 2011 through December 2012
LEROY ANDERSON DAM NO. 72-9
Santa Clara County

Date of photo 10/10/06
Photo shows temporary drill rig access roads and 2 drill rigs on dam crest for DIP

Prepared for:

State of California
Department of Water Resources
Division of Safety of Dams
P.O. Box 942836
Sacramento, CA 95236

Prepared by:
Santa Clara Valley Water District
5750 Almaden Expressway
San Jose, CA 95118

January 2013

2012 SURVEILLANCE REPORT
December 2011 through December 2012
LEROY ANDERSON DAM NO. 72-9
Santa Clara County

The analysis and interpretation of the instrumentation and other relevant data presented in this report has involved the application of certain graphical and statistical interpretive techniques common to the geosciences and earth dam engineering professions. The conclusions presented in this report were developed upon evaluating the performance of all instruments and other pertinent data during the specified period, and represent the professional judgment of its author. This report was published on January 16, 2013.

Report prepared by:

JAMES LEWIS NELSON
No. 1463

James L. Nelson, C.E.G.
Senior Engineering Geologist
Dam Safety Program Unit

Quality Control/Quality Assurance

This report has been reviewed and approved for publication by the undersigned professional engineers. attest and confirm that the report was prepared by the individual who signed the report under my immediate direction and supervision and that the conclusions and recommendations presented herein are reasonable and supported by District management.

Reviewed and approved by:

Engineering Unit Manager
Dam Safety Program Unit

Reviewed by:

Mooers

Michael Mooers, P.E.
Associate Engineer
Dam Safety Program Unit

REGISTERED PROFESSIONAL ENGINEER
MICHAEL R. MOOERS
No. CE 47629
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CIVIL ENGINEERING
STATE OF CALIFORNIA

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1.0 EXECUTIVE SUMMARY

This 2012 Surveillance Report summarizes the Santa Clara Valley Water District's (District) evaluation of Leroy Anderson Dam (Anderson Dam) No. 72-9 and reservoir located in southern Santa Clara County, California, for the surveillance period from December 1, 2011 through December 31, 2012. Our review of the surveillance data and our periodic safety inspections indicate that Anderson Dam and appurtenant structures appear to show normal response to their environment, aging process, and external events. There were no major incidents or changes at the dam during 2012. During the period of this report, there were no surveillance instrumentation alarm conditions. There are no substantive changes in dam or reservoir response compared to previous years.

The District will continue with the current monitoring program and safety inspections and will keep DSOD informed of any significant changes pertaining to the surveillance or performance of Anderson Dam. During the current reporting period, there were no new activities at the site that would impact monitoring of this facility.

2.0 INTRODUCTION

2.1 Scope and Purpose

The last surveillance report for Anderson Dam was published December 2011 (Nelson, 2011b). The focus of this 2012 annual surveillance report is to review the data for overall accuracy and to make assessments of general data trends. If any significant geotechnical or operational events have occurred (i.e., earthquakes, sustained elevated reservoir levels, significant operational or maintenance changes, or dam instrumentation/monitoring changes), these are addressed to the appropriate level in this report. This report provides historic data plots covering the last 10 years (since ~ 2002) or since the installation date if less than ten years of instrument readings. The reader is referred to previous reports for earlier observations.

This report also addresses Division of Safety of Dams (DSOD) comments from field inspection reports regarding the District’s surveillance reporting. No annual DSOD inspections were performed during the current reporting period. The last annual inspection was performed on February 14, 2011. We do not anticipate DSOD will require any modifications or changes to the surveillance reporting of Anderson Dam.

2.2 Recent Studies

2.2.1 Anderson Dam Seismic Retrofit Project (ADSRP) Planning Consultant

Board of Consultants Meeting No. 2 was held on November 15 and 16, 2012 for the Anderson Dam Seismic Retrofit Project (ADSRP). A final planning report is scheduled for submittal in March 2013. The ADSRP will enter the design phase in May 2013. Completion of retrofit construction is planned for October 2018. After the retrofit is complete the District will install new surveillance instruments to replace existing sensors that are impacted by the retrofit.

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3.0 BACKGROUND INFORMATION AND METHODOLOGY

3.1 General Surveillance

Figure 1 shows the locations of crest monuments, spillway training wall monuments, pneumatic, vibrating wire and open well piezometers, accelerometers, and the spillway underdrain weirs at Anderson Dam. Transverse and longitudinal sections are shown in Figures 2 through 4. Specifically, Figure 2 presents a transverse cross section A-A' through a minor section of the left abutment of the dam. Figure 3 presents cross section B-B' near the maximum section of the dam. Figure 4 presents a longitudinal section C-C' along the crest. The sections show vibrating wire piezometers, pneumatic piezometers, and open well piezometers OW-1, OW-2 and OW-3.

Table 1 (page 7) presents a list of locations for each vibrating wire piezometer (VWP) and open well piezometers OW-2 and OW-3. Table 2 (page 8) summarizes piezometric surface elevations (PSE in ft) of pneumatic piezometers and newer open well piezometers, and Table 3 (page 14) summarizes spillway underdrain flow. Tables 4 and 5 (pages 17 and 18, respectively) summarize survey data from the dam crest and spillway training walls. Table 6 (page 19) presents a list of pertinent data of each in-place inclinometer sensor (IPIs). All surveillance data are also shown graphically on Figures 5 through 18, and discussed later in the report.

During the time period covered by this report, the District monitored 2 pneumatic piezometers in the dam, 2 spillway underdrain seepage weirs, 15 dam crest survey monuments, 2 spillway training wall survey monuments, 3 open well piezometers, 31 vibrating wire piezometers and 6 in-place inclinometer sensors (IPIs).

All new data covered in this report is presented in tabular form, and plotted to facilitate review. For the period of this report, data were collected annually for survey monuments and monthly for pneumatic piezometers, open wells, and underdrain weirs. Data were collected approximately daily from the vibrating wire piezometers. Crest monuments were surveyed at the times indicated (typically near the end of every year).

All elevation data presented in this report have been adjusted for the current datum used by the District Dam Safety Program, which is the North American Vertical Datum (NAVD) 1988, which is 2.80 feet higher than the old datum, National Geodetic Vertical Datum (NGVD) 1929, at this location.

During the period of this report, there have been minimal changes in reservoir elevations (total excursion of ~10 feet) and relatively low reservoir elevations (between ~44 and 54 feet below spillway lip). These are much lower values than in 2011 (Nelson, 2011b) with elevations that correspond to a dry period in 2002 to 2004. The maximum reservoir elevation achieved in January 1, 2012 of el. 583.9 ft represents a progressively decreasing reservoir since a peak in 2011. In this report, vibrating wire piezometer plots are grouped and presented as standard time series plots of piezometer and reservoir.

Reported rainfall is measured at District Rain Gauge No. 41-2073, which is located a few hundred feet southeast of the left abutment of Leroy Anderson Dam.

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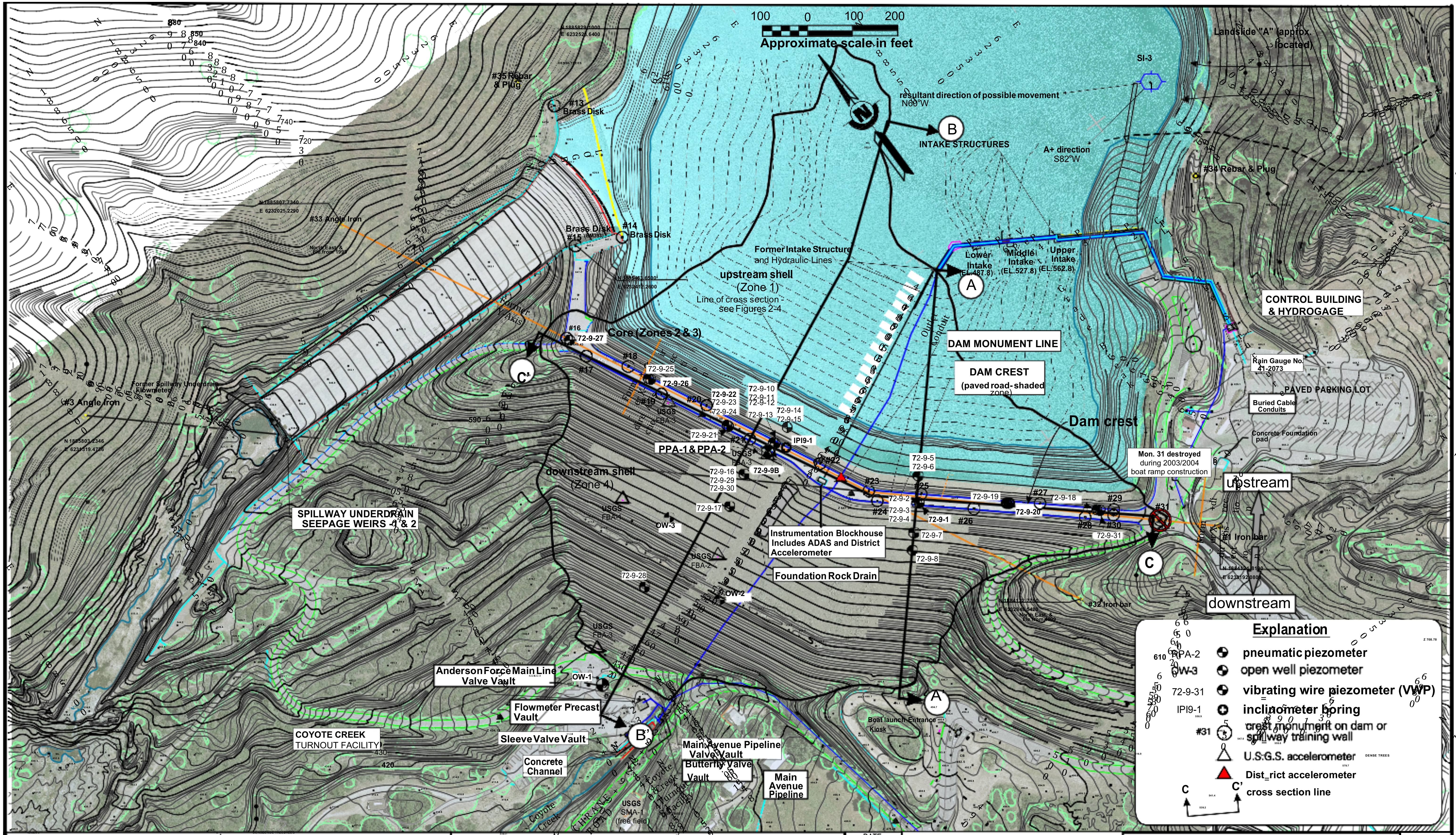


Reference information and notes:

1) This map is a compilation of aerial mapping, survey field data, and digitized construction maps. Maximum error could be **± one foot vertical and horizontal; error greater for upstream topographic lines (see note 7)**

2) Grid is based on California Coordinate System, Zone III, NAD 83.

3) Elevations based on N.G.S. Vertical datum, NAVD 88. The DE between NGVD 29 and NAVD 88 is 2.80’

4) Photogrammetric mapping: Transvision, Photo date 12/11/97; color photo date 2006

5) file W:\geology\DAMS\Historic Dam Geology\anderson\ANDHistgeo.cdr

6) selected 1987-88 dam raise values in feet shown in red

7) upstream dam topography (dashed lines) from as-built 1988 “Leroy Anderson Dam Intake Structure Modification, Sheet 2, scale 1”=100’, dated 1-8-88, from 10-7-87 aerial photography, modified to NGVD 88

DATE	**12/08/11**
DESIGN	**JLN**
DRAWN	**JLN**
CHECKED	**SW**

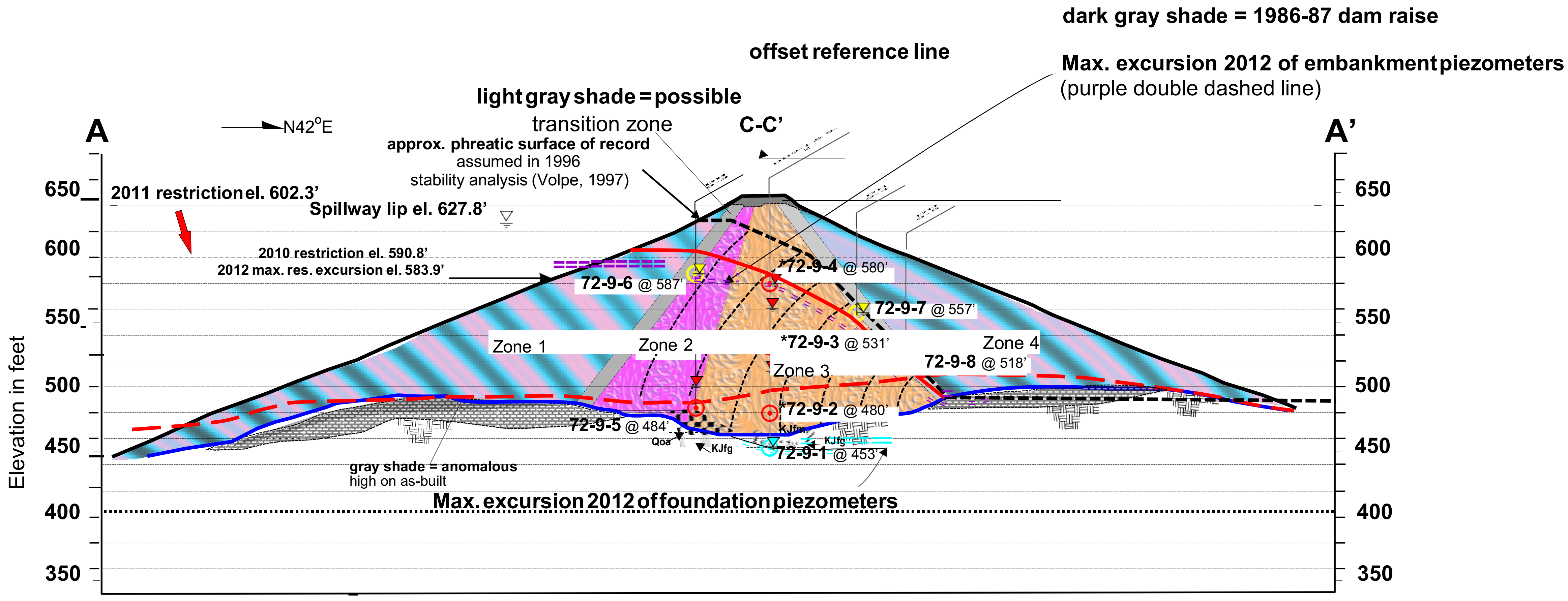
Santa Clara Valley Water District

Topographic Map
Surveillance Instrumentation
Leroy Anderson Dam

SCALE
1” = 200’

FIGURE
1

Section A-A’ (sta. 6+00)


dark gray shade = 1986-87 dam raise
offset reference line
Max. excursion 2012 of embankment piezometers
(purple double dashed line)
light gray shade = possible
transition zone
C-C’
A
N42°E
A’
approx. phreatic surface of record
assumed in 1996
stability analysis (Volpe, 1997)
2011 restriction el. 602.3’
Spillway lip el. 627.8’
2010 restriction el. 590.8’
2012 max. res. excursion el. 583.9’
72-9-6 @ 587’
*72-9-4 @ 580’
72-9-7 @ 557’
Zone 1
Zone 2
*72-9-3 @ 531’
Zone 4
72-9-8 @ 518’
Zone 3
*72-9-2 @ 480’
72-9-5 @ 484’
Qoa
KJfg
KJfm
KJfg
72-9-1 @ 453’
gray shade = anomalous
high on as-built
Max. excursion 2012 of foundation piezometers
Elevation in feet
650
600
550
500
450
400
350
650
600
550
500
450
400
350

Explanation

boring number

72-9-8 ⊙ vibrating wire piezometer

excavated topography (as-built) adjusted to DIP drill hole logs

excavated topography (as-built) corrected 2.8’ for new datum

original topography corrected 2.8’ for new datum

* = installed using grout-in methods (see Nelson, 2009b)

all other piezometers installed using sand-pack methods

Embankment/Fill Units from DIP/SSE1A

Zones 1 (downstream) and 4 (upstream): rockfill

Transition Zones, downstream and upstream

Zone 2 upstream core

Zone 3 downstream core

Bedrock & Soil Foundation Units from DIP/SSE1B

Qoa/Qc = Quaternary older alluvium and/or colluvium

QTsc = Plio-Pleistocene Santa Clara Fm

KJfm = Franciscan Complex melange

KJfg = Franciscan Complex greenstone

2012 max excursion

⊙	▼
red = embankment	embankment
yellow = transition zone	transition zone
green = colluvium/alluvium	colluvium/alluvium
blue = foundation	foundation bedrock

Phreatic Surfaces & Equipotential Lines

Phreatic surface of record Volpe, 1997

Phreatic surface Action Level - tied to 2011 res. restriction

2012 maximum excursion embankment piezometers

2012 maximum excursion foundation piezometers

approx. equipotential lines (GEI, 2009)

Notes:
1) File: W:\geology\dams\Historic_Dam_Geology\Anderson\andxsecA-A’rev.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80’ higher than NGVD 1929

DATE 11/27/12
DESIGN JLN
DRAWN JLN
CHECKED SW

Santa Clara Valley Water District

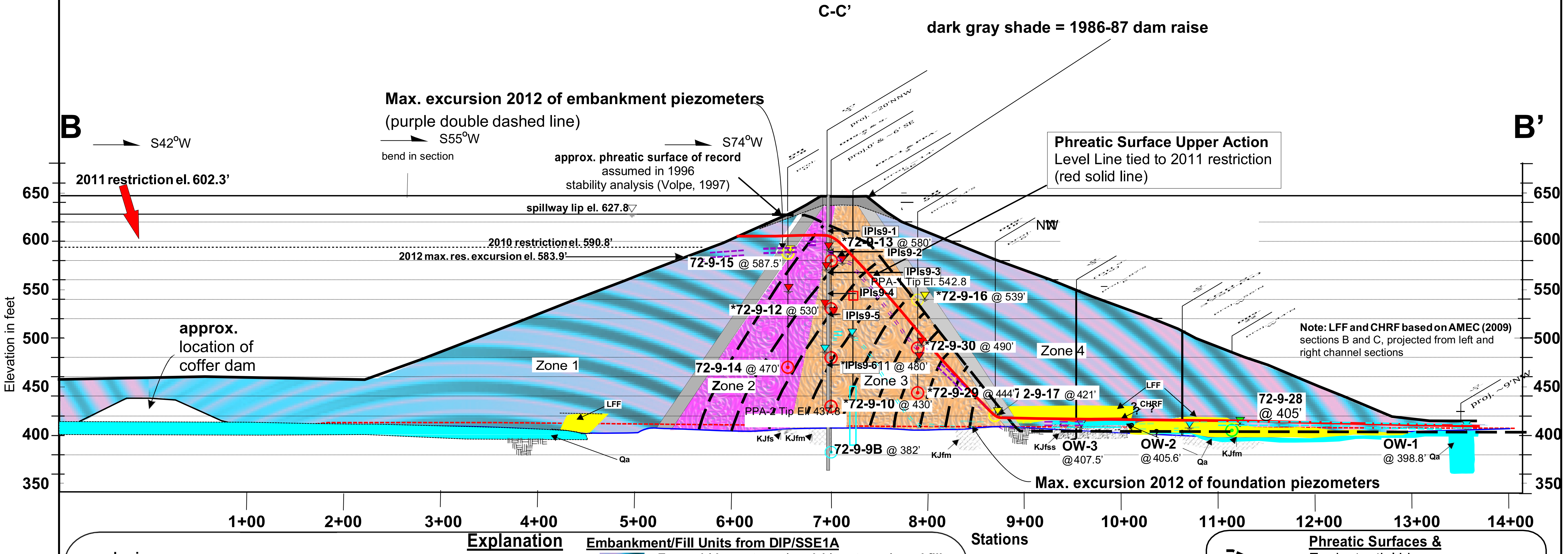
Cross Section A-A’

Leroy Anderson Dam

SCALE 1”=100’

FIGURE 2

Section B-B' (transverse max section along thalweg)



Explanation

boring number

72-9-28 ⊙ vibrating wire piezometer

IPI9-1 automated slope indicator

DH9-20 geophysical

DH9-20 lithologic logging

excavated topography (as-built) corrected 2.8' for new datum

excavated topography (as-built) adjusted to DIP drill hole logs

original topography corrected 2.8' for new datum

*=installed using grout-in methods (see Nelson, 2009b)
all other piezometers installed using sand-pack methods

Embankment/Fill Units from DIP/SSE1A

- ▨ Zones 1 (downstream) and 4 (upstream): rockfill
- ▨ Transition Zones, downstream and upstream
- 🟪 Zone 2 upstream core
- Zone 3 downstream core
- 🟧 Construction haul road fill (CHRF)
- 🟨 Lower Finer Fill (LFF), downstream and upstream

Bedrock and Foundation Soil Units from DIP/SSE1A

- 🟦 Qa/Qc = Quaternary alluvium and/or colluvium
- KJfm = Franciscan Complex melange
- KJfss = Franciscan Complex graywacke sandstone
- ⊙ red = embankment
- ⊙ yellow = transition zone
- ⊙ green = colluvium/alluvium
- ⊙ blue = foundation

2012 max excursion

- ▼ embankment
- ▼ transition zone
- ▼ colluvium/alluvium
- ▼ foundation bedrock

Phreatic Surfaces & Equipotential Lines

- Phreatic surface of record Volpe, 1997
- Phreatic surface Upper Action Level - tied to 2011 res. restriction
- 2012 maximum excursion embankment piezometers
- 2012 maximum excursion foundation piezometers
- approx. equipotential lines (GEI, 2009)

Notes:
1) File: W:\geology\dams\historic dam geology\anderson\andxsecB-B'rev.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929
3) Downstream and upstream foundation materials taken from AMEC (2010 draft)

DATE	11/26/12
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Santa Clara Valley Water District

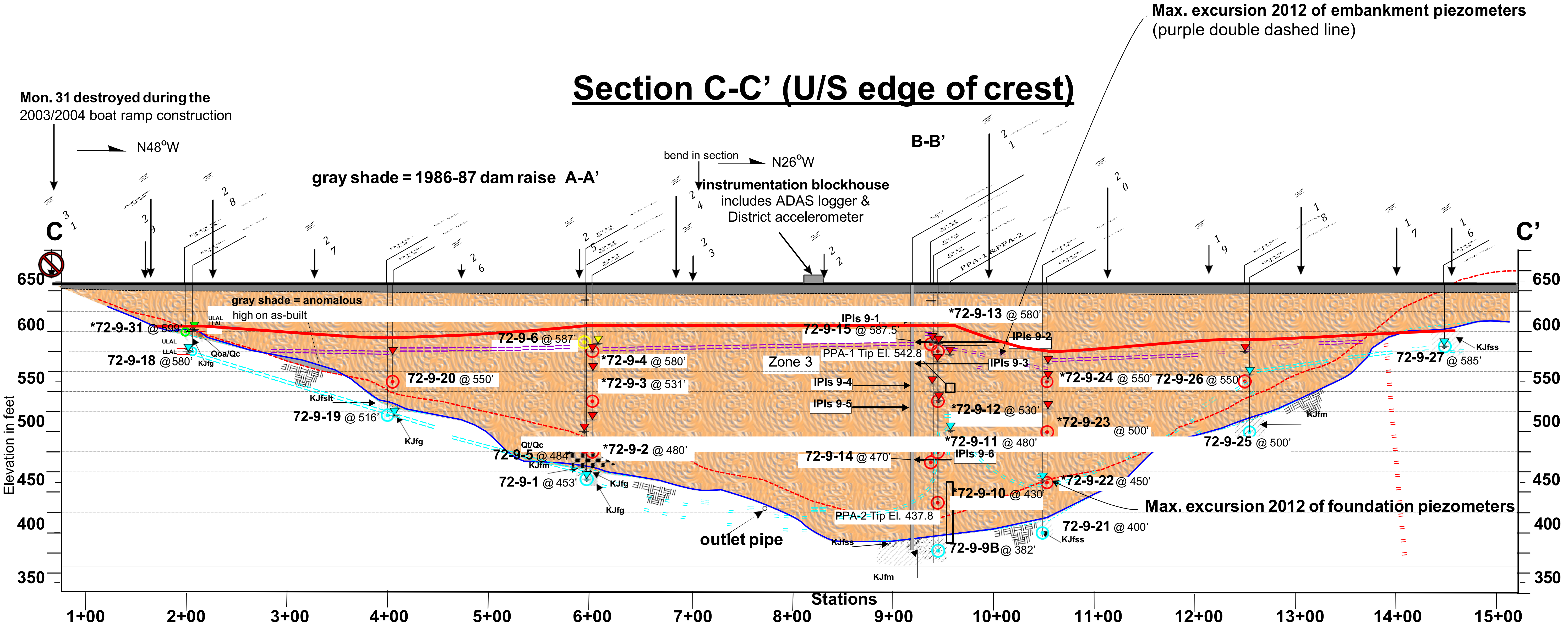
Cross Section B-B'

Leroy Anderson Dam

SCALE
1"=100'

FIGURE
3

Section C-C' (U/S edge of crest)



Explanation

boring number

72-9-27 vibrating wire piezometer

IPI9-1 automated slope indicator

geophysical/ lithologic logging

Embankment/Fill Units

▨ Zone 3 downstream core

Bedrock and Foundation Soil Units from DIP

▨ Qoa/Qc = Quaternary older alluvium and/or colluvium

▨ KJfm = Franciscan Complex melange

▨ KJfg = Franciscan Complex greenstone

▨ KJfss = Franciscan Complex sandstone

excavated topography (as-built) corrected 2.8' for new datum

excavated topography (as-built) adjusted to DIP drill hole logs

original topography corrected 2.8' for new datum

* = installed using grout-in methods (see Nelson, 2009b)
all other piezometers installed using sand-pack methods

- ⊙ red = embankment
- ⊙ yellow = transition zone
- ⊙ green = colluvium/alluvium
- ⊙ blue = foundation

2012 max excursion

- ▼ embankment
- ▼ transition zone
- ▼ colluvium/alluvium
- ▼ foundation bedrock

Phreatic Surfaces

Phreatic surface Action Level
- tied to 2011 res. restriction

2012 maximum excursion
embankment piezometers

2012 maximum excursion
foundation piezometers

Notes:
1) File: W:\Geology\DAMS\Historic_Dam_Geology\Anderson\andxsecC-CDIP.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929

DATE	11/26/12
DESIGN	JLN
DRAWN	JLN
CHECKED	SW

Santa Clara Valley Water District

Longitudinal Cross Section C-C'

Leroy Anderson Dam

SCALE
1"=100'

FIGURE
4

3.2 Changes to Surveillance Reporting

The following are changes and additions made to surveillance data collection and general surveillance reporting at Anderson Dam since the last report (Nelson, 2011b).

The following field work activities resulted in updates to the instrumentation and monitoring:

1) As a result of ADAS power issues that have limited the collection of viable IPIs data since initial installation of the system at Anderson Dam, the District upgraded the power supply at the crest IPIs location on February 13, 2012. This appears to have solved the power issues.

2) On August 16, 2012 the District replaced faulty in-place inclinometer IPI9-3-6 sensor with a new sensor that is currently providing viable data. The new sensor has the same designation as the original sensor.

3) In November 2012 the District addressed safety issues for personnel collecting spillway weir readings by constructing a ladder to safely access the weirs.

In addition, newly developed action levels for each instrument are summarized in Appendix A on Tables A1 through A5. Tables A1 and A2 are action levels for all piezometers. Table A3 summarizes spillway underdrain weir discharge action levels, Table A4 summarizes survey monument action levels, and Table A5 summarizes in-place inclinometer sensor action levels.

The upper and lower action levels tied to reservoir levels are included graphically for each piezometer in section view in Figures 2 through 4, and on cross plots in Figures 6 through 13. Action levels for the underdrain weirs are shown graphically in Figure 14. Specific reservoir levels for each piezometer are defined by historic data based on methods discussed in Appendix A. The upper and lower boundary action levels are summarized on Tables A1 and A2 and are tied to the 2011 reservoir restriction at elev. 602.3 feet. This report also shows graphically on the cross sections (Figures 2 through 4) the maximum 2011-2012 response of each piezometer.

The 1996 stability analysis of record for establishing the phreatic surface is herein considered to be the third Part 12D Safety Inspection and Report by R.L. Volpe & Associates (1997). The phreatic surface from sections developed in 1996 by R.L. Volpe & Associates (1997) for stability analysis is shown in Figures 2 and 3. Also, for this report we added approximate equipotential lines developed by GEI (2009) to Figures 2 and 3.

4.0 SURVEILLANCE INFORMATION

This report graphically depicts surveillance data as time-series plots of reservoir levels and rainfall (Figure 5), time-series and cross plots of piezometers (Figures 6 through 13), time-series and cross plots of spillway underdrain weirs (Figure 14), and time-series plots of crest and spillway training wall monument surveys (Figures 15 through 17).

As part of our quality assurance/quality control, reservoir elevation data and piezometric surface elevation data (PSE) are plotted and reviewed in the form of 1) time series plots (PSE versus time) and 2) cross plots (PSE versus reservoir elevations). Piezometer cross plots of all VWPs are shown as insets in Figures 6 through 13 and a weir seepage discharge cross plot is shown as Inset Figure 14. Also shown for reference are previous and current reservoir restrictions.

4.1 Description of Instrumentation and ADAS

The reader is referred to the DSSMP (Nelson, 2009a) for a complete description of all instrumentation and ADAS at Anderson Dam.

4.2 Outlier Data

Surveillance data that lies outside established action levels summarized on Tables A1 through A5 are considered outlier data. The District follows formal procedures to deal with outlier data to determine if they represent unsafe or alarm conditions.

There were no significant instances of outlier data during the current reporting period.

4.3 Data Gaps

Gaps that occurred in the various data sets are discussed in the applicable sections, *Section 4.6.6* for piezometers, *Section 4.7.2* for spillway underdrain flows *Section 4.8.4* for crest survey monuments, *Section 4.8.7* for spillway training wall monuments and *Section 4.9.3,* for in-place inclinometer sensor (IPIs). Except for the absence of data from the spillway underdrain weirs, one vibrating wire piezometer, and IPIs data, no significant gaps occurred during the current reporting period.

Significant data gaps for ADAS instruments, and manual data collected from piezometers and underdrain flow weirs is defined as the absence of recorded instrument data for a period greater than about 1 month. A data gap for survey data is considered the absence of data over a period of plus or minus ~6 months outside the normally scheduled yearly survey.

The three items discussed below are the only significant gaps that occurred during the current reporting period. Data for the spillway underdrain weir were not reported for most of the current period due to access safety issues. Due to power issues with VWP-8, there was a data gap of approximately 4 months from February to June 2012. Since the IPIs were reset in August 2012 due to installation of the bottommost sensor, and the sensors appear to be experiencing a period of adjustment, we decided to not include data plots of IPIs. Therefore, there is a gap of ~5 months in the IPIs data. Except for these minor issues, ADAS stations are currently working properly with no significant issues.

4.4 Reservoir Restrictions

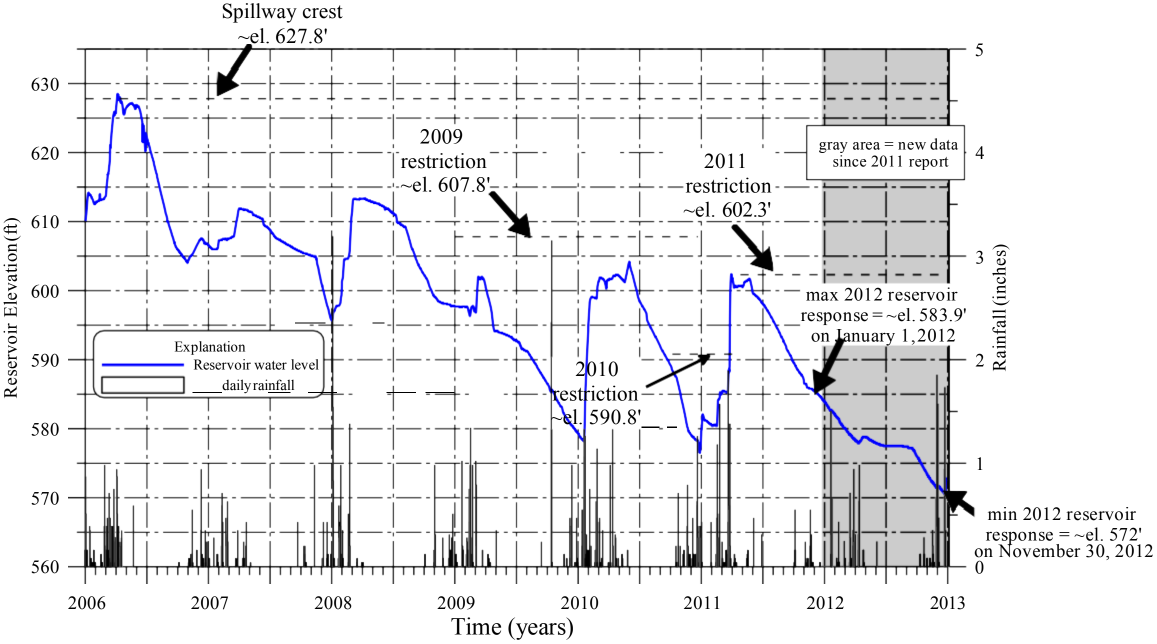
Anderson reservoir is under a current restriction of 45 feet at elev. 602.3 feet (NAVD88) established in 2011. This restriction was approved by FERC and DSOD. The current restriction will be in place until the seismic retrofit of the dam is completed, which is currently anticipated to be the end of 2018.

Figures 5 through 14 show the various reservoir restrictions.

4.5 Annual Reservoir Fluctuation

Figure 5 shows the detail of reservoir fluctuation from 2006 through most of 2012 with gray shading that denotes recent data during the current surveillance period from January 2012 to the present.

During the period of this report, there have been minimal changes in reservoir elevations (total excursion of ~10 feet) and relatively low reservoir elevations (between ~44 and 54 feet below spillway lip). These are much lower values than in 2011 (Nelson, 2011b) with elevations that correspond to a dry period in 2002 to 2004. The maximum reservoir elevation was achieved in early 2011 with progressively decreasing reservoir levels to the present.



Notes: 1) basis of elevations is NAVD 1988 - values are 2.8 feet higher than NGVD 1929
2) file W:\geology\dams\annual dam safety reports\DSOD\Anderson\2012\piez\Andresplot-12

Figure 5. Daily Reservoir Elevation and Rainfall 2006-2012

The maximum reservoir excursion for 2012 was elev. 583.9 feet (~44 feet below spillway lip elev.) on January 1, 2012. In recent years due to reservoir restrictions there has been an overall lowering of maximum reservoir excursions. The last time Anderson Reservoir spilled was in April 2006 (Nelson and Volpe, 2006). For the current reporting period, the reservoir level has been well below the 2011 restriction at elev. 602.3 ft. During the current reporting period, the reservoir level has progressively lowered. The minimum elev. of 572 feet was on November 30, 2012.

The preponderance of rainfall for any given calendar year typically occurs during January through April/May (locally known as a “water year”).

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4.6 Piezometers

Table 1 summarizes pertinent data of the vibrating wire piezometers (VWP), original pneumatic piezometers, and open well piezometers, including location in the dam, tip elevation and surface elevation.

Table 1
Locations of Vibrating Wire Piezometers
Pneumatics and Open Well Piezometers
Anderson Dam

Embankment Piezos

Downstream Core Zone 3	Tip Elev. (ft)	Surface Elev. (ft)
72-9-02*	480	647
72-9-03*	531	647
72-9-04*	580	647
72-9-05	484	631
72-9-10*	430	647
72-9-11*	480	647
72-9-12*	530	647
72-9-13*	580	647
72-9-20	550	647
72-9-22*	450	647
72-9-23*	500	647
72-9-24*	550	647
72-9-26	550	647
72-9-29*	444	614
72-9-30*	490	614
PPA-1	540	647
PPA-2	435	647
Upstream Core Zone 2	Tip Elev. (ft)	Surface Elev. (ft)
72-9-14	470.0	630.0

Transition Zone

Downstream	Tip Elev. (ft)	Surface Elev. (ft)
72-9-07	557	619
72-9-08	518	602
72-9-16*	539	614
72-9-17	421	583
Upstream	Tip Elev. (ft)	Surface Elev. (ft)
72-9-06	587.0	631
72-9-15	587.0	630.0

Foundation Fill Lower Finer Fill

Foundation	Tip Elev. (ft)	Surface Elev. (ft)
OW-2	406	508

Bedrock Foundation

Foundation	Tip Elev. (ft)	Surface Elev. (ft)
72-9-01	453	647
72-9-9B	382	647
72-9-18	580	647
72-9-19	516	647
72-9-21	400	647
72-9-25	500	647
72-9-27	585	647

Alluvial/Colluvial Foundation

Foundation	Tip Elev. (ft)	Surface Elev. (ft)
72-9-28	405	486.0
72-9-31*	600	647
OW-1	399	417
OW-3	408	551

Note:
1) * = piezometer installed using grout-in methods
2) all other piezometer installed using sand-pack methods
3) W:\Geology\DAMS\Annual Dam Safety Reports\FERC\AnnualReports\2011\piez\Andtab1-11.xls

4.6.1 Pneumatic Piezometers

Two pneumatic piezometers (PPA-1 and PPA-2), installed in 1975, show slight fluctuations and response to changes in reservoir levels but are still operational after 38 years of service.

4.6.2 Vibrating Wire Piezometers

The District manually collected data from 31 VWPs from their installation in late December 2006 until implementation of ADAS in early December 2008. Most data since December 2008 has been automatically collected by ADAS. The locations of the VWPs are shown in plan view in Figure 1 and in section views in Figures 2, 3, and 4.

As summarized in Table 1, locations of the piezometers include 16 VWPs in the downstream core (Zone 3) of the embankment, 1 VWP in the upstream core (Zone 2) (with core piezometers shown as red symbols in Figures 2, 3, and 4), 4 VWPs in the downstream transition zone (yellow symbols), 2 VWPs in the upstream transition zone, 2 VWPs in alluvium/colluvium (green symbols), and 7 VWPs in foundation Franciscan Complex bedrock (blue symbols).

4.6.3 Open Well Piezometers

The locations of the open well piezometers are shown in Figures 1 and 3. As summarized in Table 1, piezometer OW-2 targets the phreatic surface of a lower fine-grained unit of rockfill embankment encountered during the SSE1A investigation and identified as the "Lower Finer Fill" (LFF) at depths between 89 feet and 105 feet (~elev. 403 feet and 419 feet). Well OW-3 targets the phreatic surface of various foundation soils including construction haul road fill and alluvium at depths between 132 feet and 141 feet (~elev. 410 feet and 418 feet).

4.6.4 Piezometer Data

Recent pneumatic and newer open well piezometer data collected since our last report (Nelson, 2011b) from December 2011 through December 2012 are summarized in Table 2.

TABLE 2
Recent Piezometric Data
Leroy Anderson Dam)

Date	Reservoir Level (ft)	PPA-1	PPA-2	OW-1	OW-2	OW-3	Monthly* Rainfall (in)
		Piezometric Surface Elevation (ft)					
12/8/11	585.2	570.8	497.0	406.2	404.7	411.6	0.0
1/15/12	582.8	576.9	500.2	406.2	406.4	412.3	2.6
2/15/12	581.3	568.3	501.5	406.1	406.5	411.6	0.9
3/15/12	579.3	567.2	493.3	406.2	406.5	411.6	3.2
4/15/12	578.2	566.1	492.3	405.9	406.5	411.7	2.3
5/15/12	578.3	566.1	488.6	405.8	406.5	411.8	0.0
6/15/12	577.8	568.3	487.6	405.8	406.6	411.7	0.2
7/12/12	577.5	569.5	492.2	405.8	406.5	411.7	0.0
8/15/12	577.5	569.5	488.6	405.8	406.5	411.7	0.0
9/19/12	577.1	569.5	491.0	406.1	406.5	411.6	0.0
10/16/12	574.7	567.2	491.0	406.3	406.5	411.6	0.5
11/19/12	572.2	565.9	484.1	406.4	406.6	412.2	3.4
12/19/12	570.8	565.9	486.3	406.3	406.6	411.8	5.5

Notes:
1) Piezometer data is Piezometric Surface Elevation (PSE in feet)
2) PSE = pressure head (ft) + elevation head (ft)
3) basis of elevations is NAVD 1988 - values in this table are 2.8 feet higher than NGVD 1929
4) Installation dates: OW-1 on 8/5/03, OW-2 on April 30, 2009, and OW-3 on May 1, 2009
5) file: W:\Geology\DAMS\Data\Pz\Anderson.xls

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The piezometer data presented in Figures 6 through 13 are time-series plots of piezometric surface elevation (PSE) vs. time for each piezometer. The PSE is defined as the sum of the piezometer tip elevation (feet) and the hydraulic pressure head (feet).

Figure 6 shows pneumatic and open well piezometric levels as piezometric surface elevation (PSE), reservoir levels, and monthly rainfall data for the most recent 10 year period from January 2002 through December 2012. Table 2 and the gray area of Figure 6 show data since our 2011 report (Nelson, 2011b).

Overall, the data indicates that fluctuations in these piezometric levels show minimal response to fluctuations in reservoir level. Pneumatic piezometers PPA-1 and PPA-2, located in the lower portion of the central clay core, consistently show minor variations in piezometric elevations under a wide range of reservoir fluctuations.

The pneumatic piezometer data appear to be providing reliable and consistent data during the entire surveillance period. Action Levels for the piezometers (PSE values) are summarized on Tables A1 and A2, Appendix A. *PSE values are well below the upper Action Levels. The values are also well above the lower Action Levels.*

As shown in Figure 6, since installation of the open wells OW-1, OW-2, and OW-3, the piezometric surface in these wells have varied over relatively narrow ranges. For 2012, piezometric elevations in OW-1 (located about 50 feet from the downstream toe of the dam) were consistently ~elev. 405.2 feet to 406.4 feet, which corresponds to a depth of ~10 ½ feet below ground surface. OW-2 has varied from elev. ~405 feet to ~408 feet and OW-3 has varied from elev. ~411 feet to 412 feet. Long-term trends of the phreatic surface in these wells have not been established.

4.6.5 Vibrating Wire Piezometer (VWP)

The maximum Anderson Reservoir elevation since installation of the VWPs and their first readings in November 2006 was about 613.4 feet on April 9, 2008, which is about 14 feet below the spillway lip. The maximum for the current reporting period was 583.9 feet on January 1, 2012, which is about 44 feet below the spillway lip.

Figures 7, 8, and 10 show 3 time-series plots of VWP surface elevation (PSE) data from the embankment versus time along sections A-A', B-B', and C-C'. Figure 11 shows plots of PSE data versus time for foundation bedrock VWPs. Figure 13 shows PSE time-series plots of transition zone VWPs. Reservoir elevation data are presented for reference. Due to various restrictions since 2009, the VWPs installed in 2007 (DIP) and 2010 (SSE1A) have not experienced possible maximum VWP excursions. The recent data obtained since our last report (Nelson, 2011b) from December 2011 through December 2012 is shown as a shaded region on Figures 7 through 13.

There are a number of pertinent observations based on VWP information to date. These are summarized below and are grouped by the piezometric response in each section of the dam.

- Core: The response of the core piezometric levels generally exhibits either minimal response with piezometer excursions that are suppressed relative to the reservoir, or

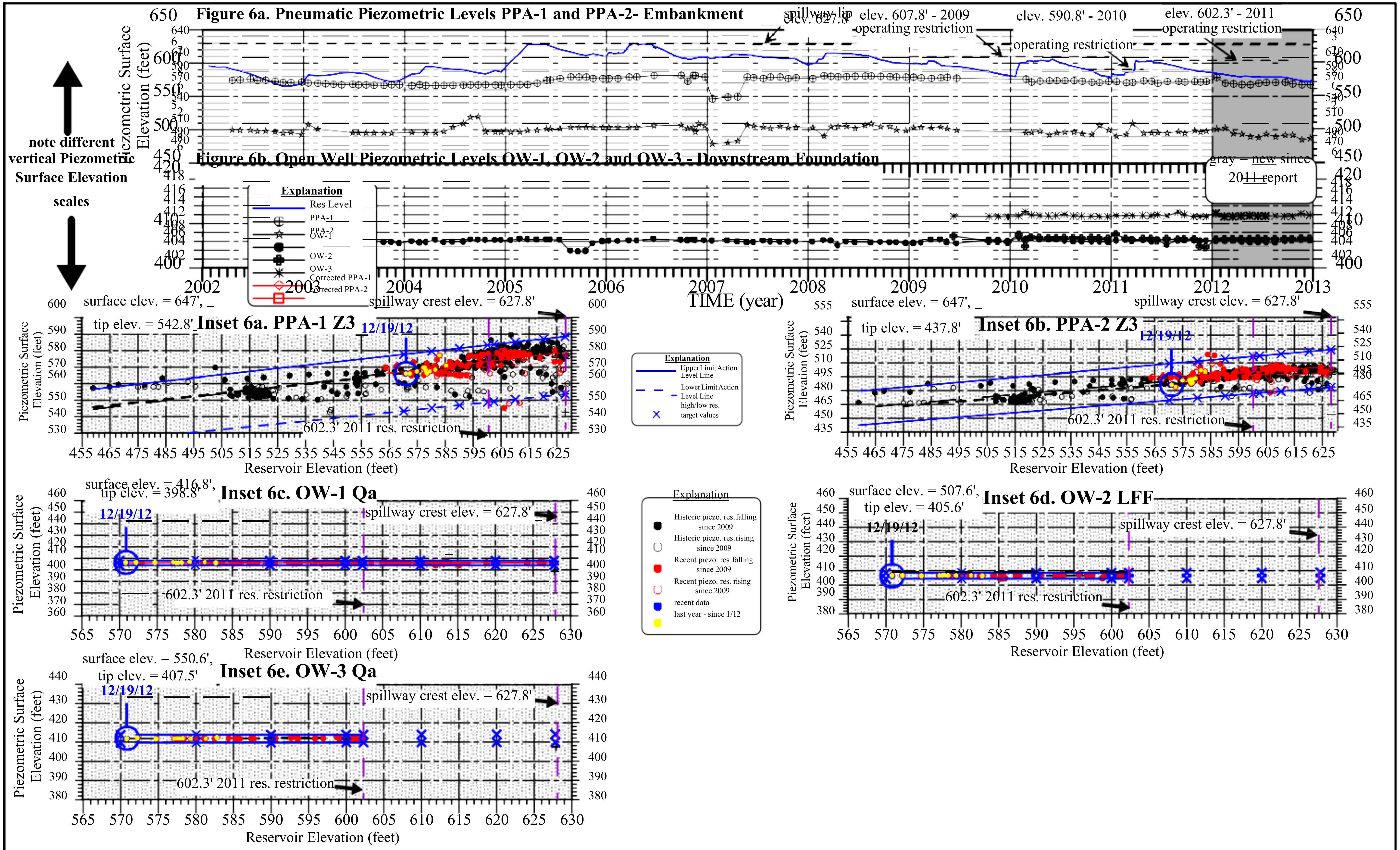


Figure 6a. Pneumatic Piezometric Levels PPA-1 and PPA-2- Embankment

Figure 6b. Open Well Piezometric Levels OW-1, OW-2 and OW-3 - Downstream Foundation

Inset 6a. PPA-1 Z3

Inset 6b. PPA-2 Z3

Inset 6c. OW-1 Qa

Inset 6d. OW-2 LFF

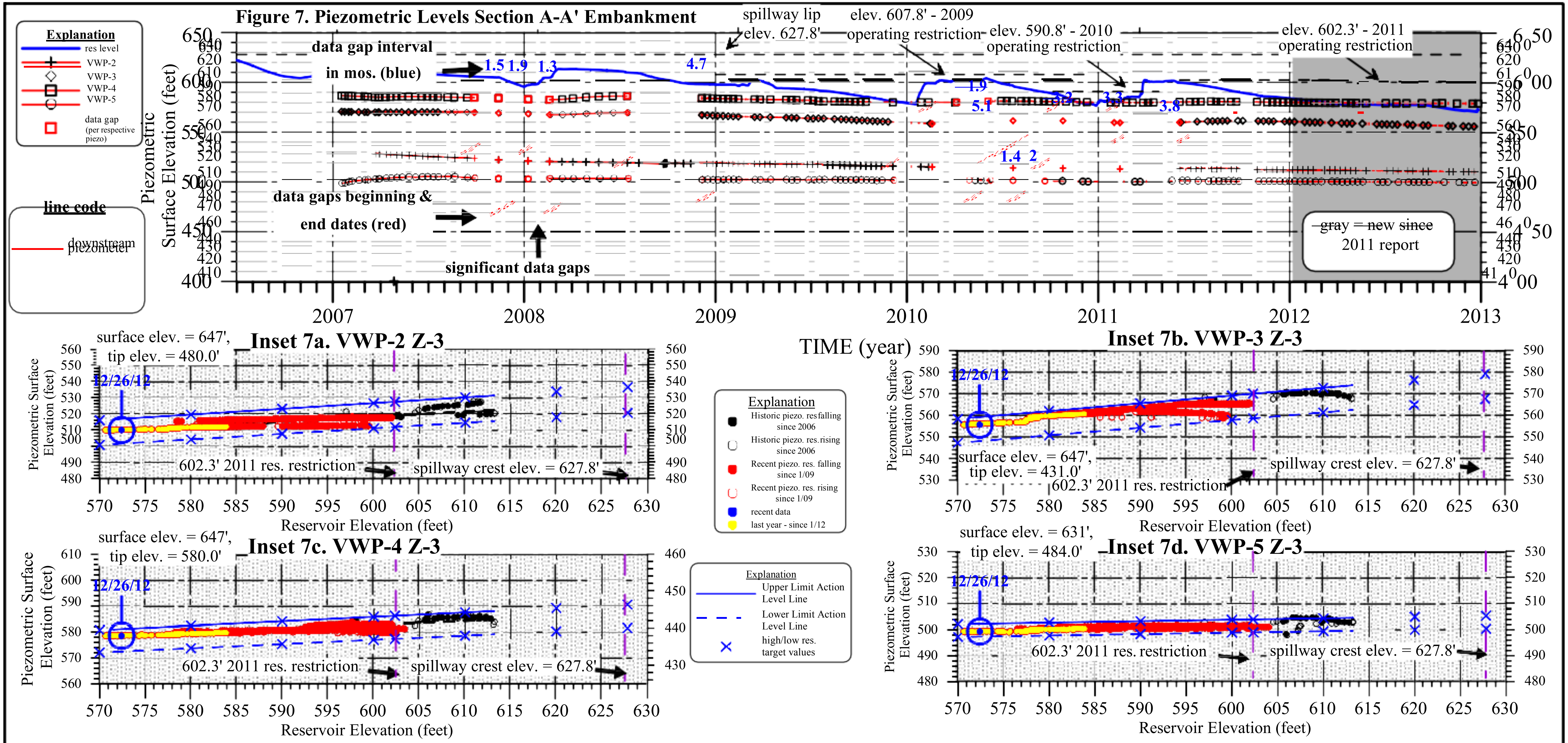
Inset 6e. OW-3 Qa

Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\Piez\Andpneu&ows-12.grf

Santa Clara Valley Water District

Recent Piezometric Data - Pneumatic and Open Wells
Embankment & Downstream Foundation
Leroy Anderson Dam

FIGURE
6



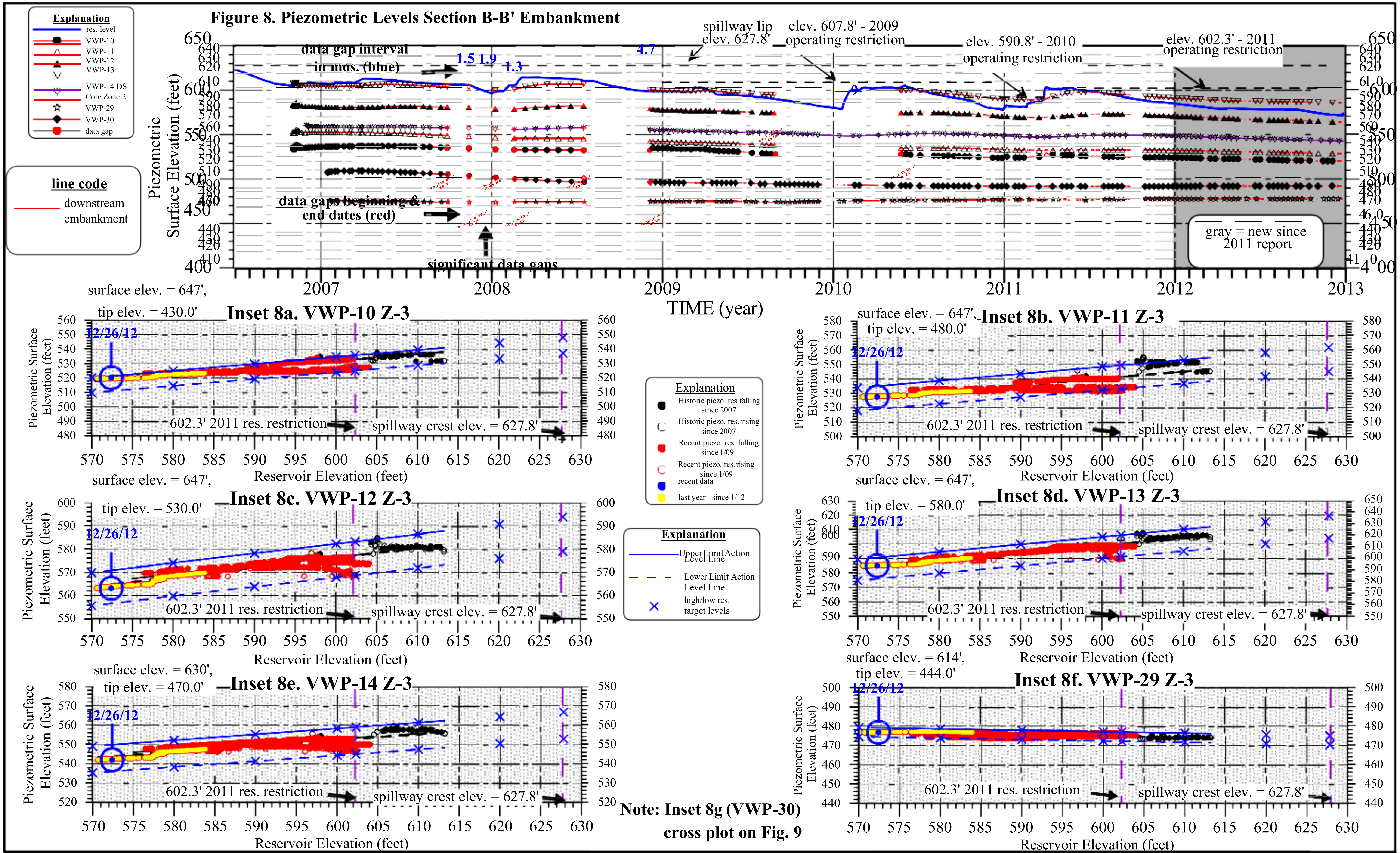
Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOd\Anderson\2012\Piez\AndSectionA-12.grf

Santa Clara Valley Water District

Recent VW Piezometric Data
Section A-A' - Embankment
Leroy Anderson Dam

FIGURE
7

Figure 8. Piezometric Levels Section B-B' Embankment



Note: Inset 8g (VWP-30) cross plot on Fig. 9

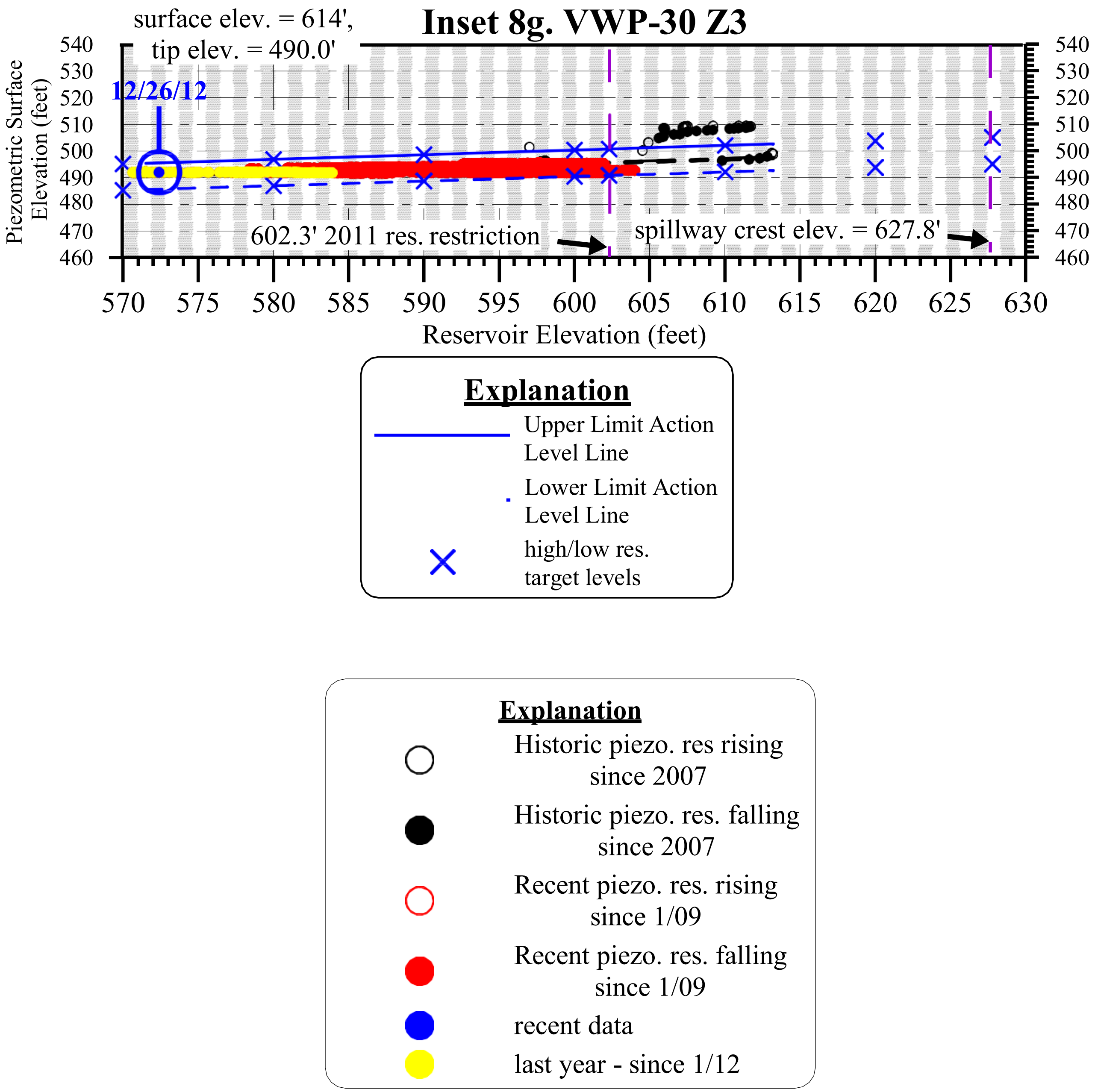
Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\Piez\AndSectionB-12.grf

Santa Clara Valley Water District

Recent VW Piezometric Data
Section B-B' - Embankment
Leroy Anderson Dam

FIGURE
8

Cross Plot Continued from Figure 8



Notes: 1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than those dated earlier than 1998

2) file W:\geology\dams\annual dam safety reports\DSOD\Anderson\2012\Piez\AndInset8g-12.grf

Santa Clara Valley Water District

Recent Piezometric Data

Inset 8g Cross Plot

Leroy Anderson Dam

FIGURE

9

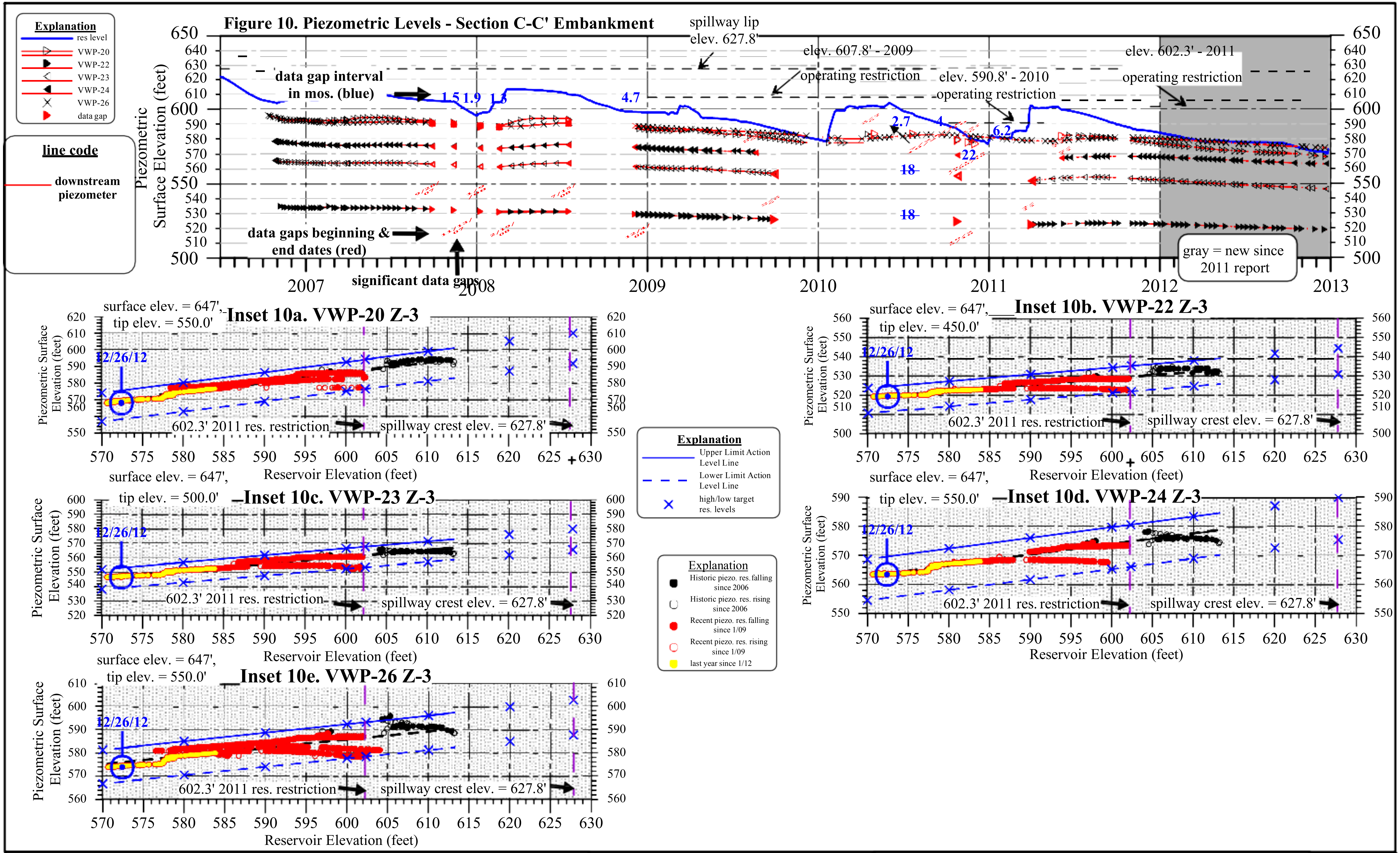


Figure 10. Piezometric Levels - Section C-C' Embankment

Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\FERC\AnnualReports\2012\Piez\AndSectionC-12.grf

Santa Clara Valley Water District

Recent VW Piezometric Data
Section C-C' - Embankment
Leroy Anderson Dam

FIGURE
10

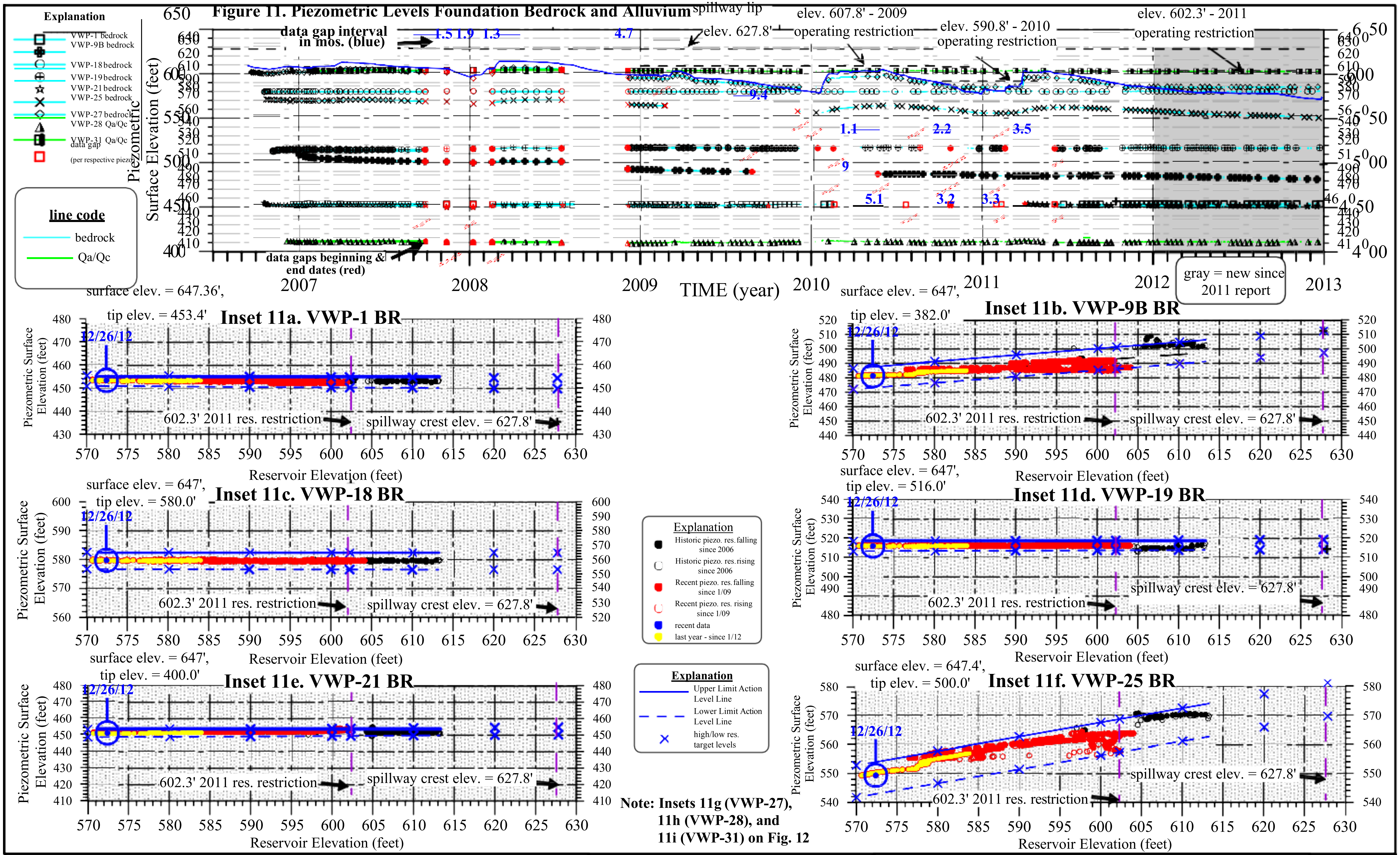


Figure 11. Piezometric Levels Foundation Bedrock and Alluvium

Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Annual Reports\Anderson\2012\Piez\AndFound-12.grf

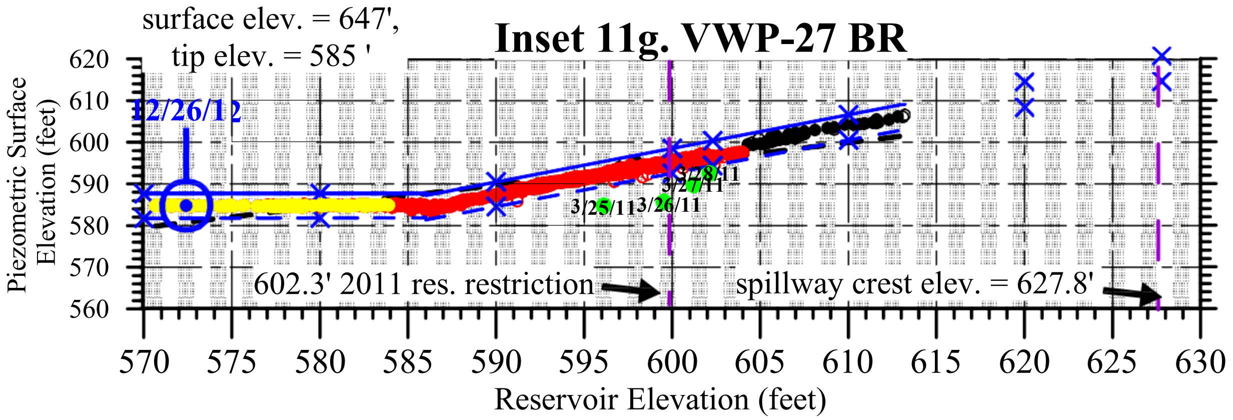
Santa Clara Valley Water District

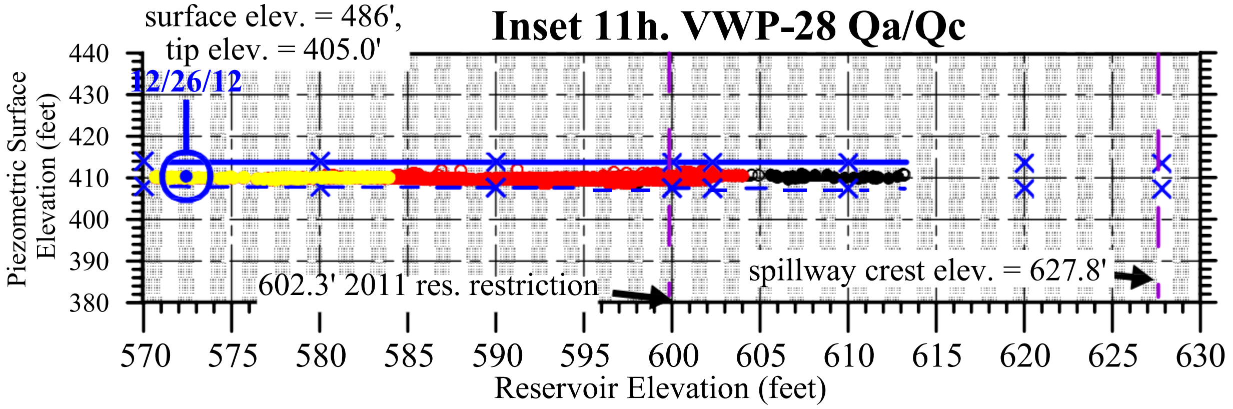
Recent VW Piezometric Data - Foundation

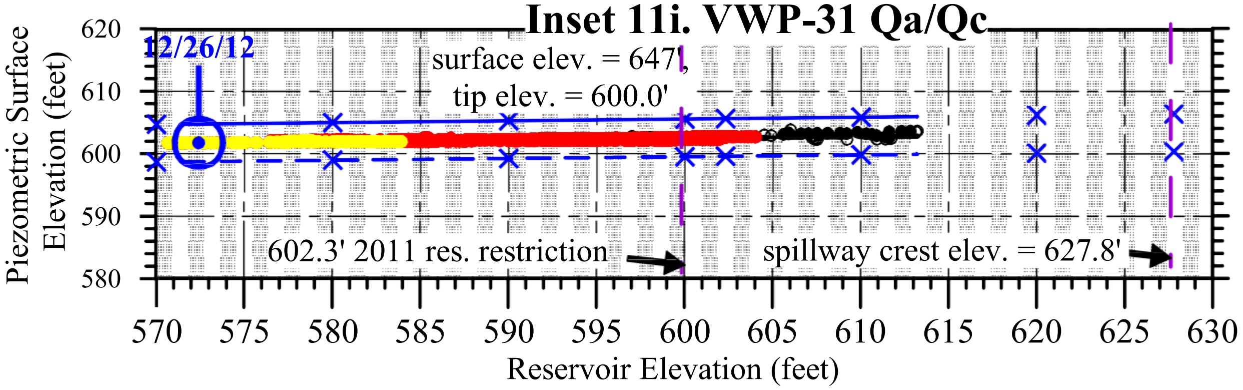
Leroy Anderson Dam

FIGURE
11

Cross Plots Continued from Figure 11







Explanation

- ▬ Upper Limit Action Level Line
- – – Lower Limit Action Level Line
- × high/low res. target levels
- ● outlier data and date

Explanation

- ● Historic piezo. res. falling
- ○ Historic piezo. res. rising
- ● Recent piezo. res. falling since 2009
- ○ Recent piezo. res. rising since 2009
- ● most recent data
- ● latest water year since 1/12

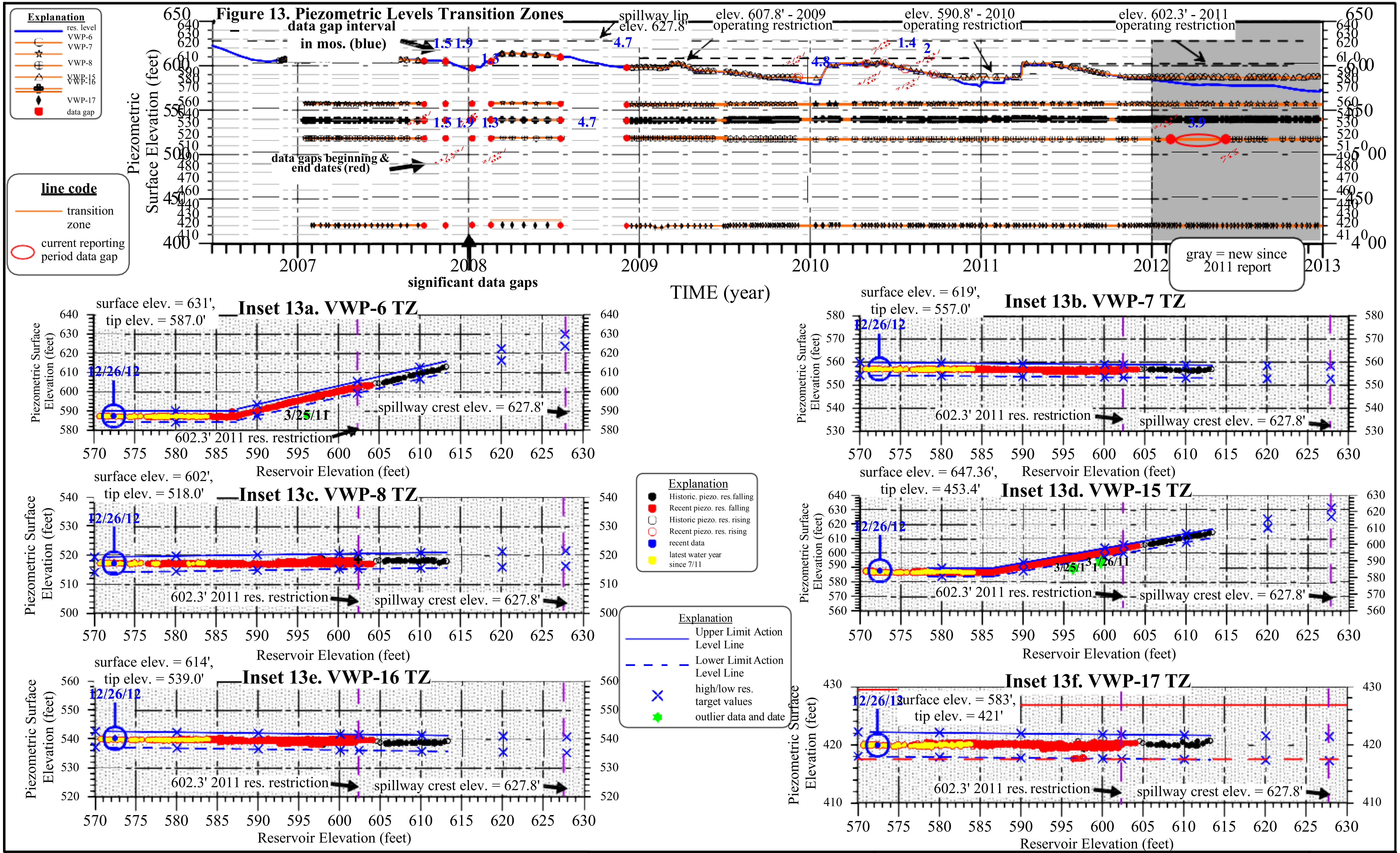
Notes: 1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than those dated earlier than 1998

2) file W:\geology\dams\annual dam safety reports\DSOD\Anderson\2012\Piez\AndInset11g-11i-12.grf

Santa Clara Valley Water District

Recent Piezometric Data
Insets 11g thru 11i Cross Plots
Leroy Anderson Dam

FIGURE
12



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\Piez\AndTZ-12.grf

Santa Clara Valley Water District

Recent VW Piezometric Data -
Transition Zones
Leroy Anderson Dam

FIGURE
13

exhibits a “flat-line” plot indicating that piezometers don’t seem to track reservoir excursions. These responses appear to be due to the low permeability clay core.

Response of core piezometers indicates that hydraulic pressures are being safely dissipated by head losses through the core in a safe and effective manner. This is based on the fact that 1) minimal response of core VWPs and pneumatic piezometers as indicated in Figures 7, 8, 10, and 11; and, 2) no significant variations in hydraulic head losses across the entire width or length of the dam in the 16 VWPs located within the U/S Zone 2 and D/S Zone 3 core sections (see Table 1).

- Foundation: Response of foundation piezometers indicates that during construction the foundation was adequately prepared including removal of surficial soils (i.e. alluvium and colluvium) beneath the core, and the fact that the vast majority of the clay core rests on, and is in direct contact with either predominantly competent Franciscan Complex bedrock or semi-consolidated Santa Clara Formation sediments.

  The majority of the foundation VWPs are measuring only a fraction of the total possible pressure head at various locations beneath the core of the dam (Figure 11).

- Left and Right Abutments: The left and right abutment VWPs (18, 31, 25, and 27) located in bedrock (Franciscan Complex and possibly Santa Clara Formation) appear to have relatively high PSE values based on their relatively high tip elevations (580 ft, 600 ft, 500 ft, and 585 ft, respectively) and the likelihood that these VWPs are located in bedrock that appears to be slightly more permeable than the clay core. Some VWPs are essentially dry (VWP 18 PSE value is close to the tip elevation) or have water levels slightly above the tip (VWP 31 has PSE values ~2 ft higher than the tip elevation). Other VWPs exhibit significant response to reservoir elevations such as VWP 25 that has PSE values that range from ~55 ft to ~64 ft higher than tip elevation and VWP 27 that has PSE values that range from ~2 ft to 15 ft higher than the tip elevation. VWP 27 is also one of the few piezometers that noticeably respond to reservoir changes.

  VWP 31 is noteworthy because, regardless of how much the reservoir drops, the minimum PSE stays at about elev. 602 ft. Currently, PSE values in VWP 31 are at ~elev. 602 ft while reservoir elevation is ~elev. 572 ft, indicating that the phreatic level in VWP 31 is ~29 ft higher than the reservoir. The tip of VWP 31 is located at a relatively high elevation (~600 ft) in the left abutment. This higher pore pressure response relative to reservoir levels likely involves storage retention or field capacity when a porous media is drained. It is also possible that local groundwater conditions govern the water level in VWP 31.

- Upstream Rockfill and Transition Zone: There is essentially no loss (dissipation) of reservoir head through the upstream rockfill shell and transition zone because the full reservoir hydrostatic head is acting along the upstream sloping face of the core. The performance of two upstream transition zone VWPs (6 and 15) is expected because the upstream rockshell and transition zones are very permeable.

- Downstream Rockfill and Transition Zone: The downstream transition zone and overlying rockfill zone are essentially dry, which indicates that the transition zone is effectively capturing the phreatic surface as it exits the downstream face of the core. Four VWPs within the downstream transition zone, including 7 and 8 in Section A-A (Figure

2), and 16 and 17 in Section B-B' (Figure 3) all measure PSE values that are essentially at or below their respective tip elevations (i.e. dry holes).

- Downstream Foundation: Downstream foundation VWPs exhibit a drop in maximum PSE value of about 4.7 feet over a horizontal distance of about 400 feet. This computes to a relatively low horizontal seepage gradient of about 0.02 (6'/400') in the downstream toe area. These piezometers include VWP 28, OW-1, OW-2, and OW-3. OW-1 is located about 50 feet beyond the downstream toe very close to the maximum section. OW-2 and OW-3 monitor the downstream foundation consisting of lower finer fill (OW-2) and haul road fill/alluvium (OW-3). Open wells OW-2 and OW-3 appear to respond similar to OW-1, with essentially no response to reservoir changes.

The piezometric levels in all piezometers tend to fall within the typical ranges of historical levels. No abnormal readings or trends are evident.

4.6.6 Piezometer Data Gaps

Due to power issues with VWP-8 there was a data gap of approximately 4 months from February to June 2012. The District is currently obtaining fairly continuous data readings from all the non-ADAS and ADAS instruments. Consequently, other than a gap in VWP-8 data, there are no significant piezometer data gaps.

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4.7 Spillway Underdrain System

The current spillway underdrain discharge monitoring program for Anderson Dam Spillway began in May 1993. From 1993 to 1999 discharge was measured only at the "center" drainage system which collects seepage in the central portion of the spillway. The "left" drainage system discharged through boulders that were providing slope protection D/S of the spillway bucket and could not be measured.

In 1999 a new weir system allowed all discharge to be measured instead of only a portion of the flow as occurred with the original center drainage system mentioned above. Weir #1 measures the seepage from the "center" drainage system but is not affected by the restriction and backpressure created by the use of a meter, as was the old system that it replaced. Weir #2 measures the seepage collected along the left (southern) side of the spillway.

4.7.1 Spillway Underdrain Flow Data

Our surveillance reports only provide historic data plots covering the last 10 years (since ~ 2002). As summarized in Table 3, the underdrain data are not being collected due to unsafe access conditions. The District constructed an access ladder to provide a safe method for reading the underdrain weirs. New data should be available after December 2012.

This report only shows plots of the weir discharge data. Historic Spillway underdrain flow data was formerly collected using a flow meter, which are summarized in previous surveillance reports. Figure 14 shows monthly rainfall and data from weirs No. 1 and No. 2 from December 2011 through December 2012. Table 3 shows recent data since the 2011 report (Nelson, 2011b). The only data collected this period was during the annual FERC inspection in April 2012.

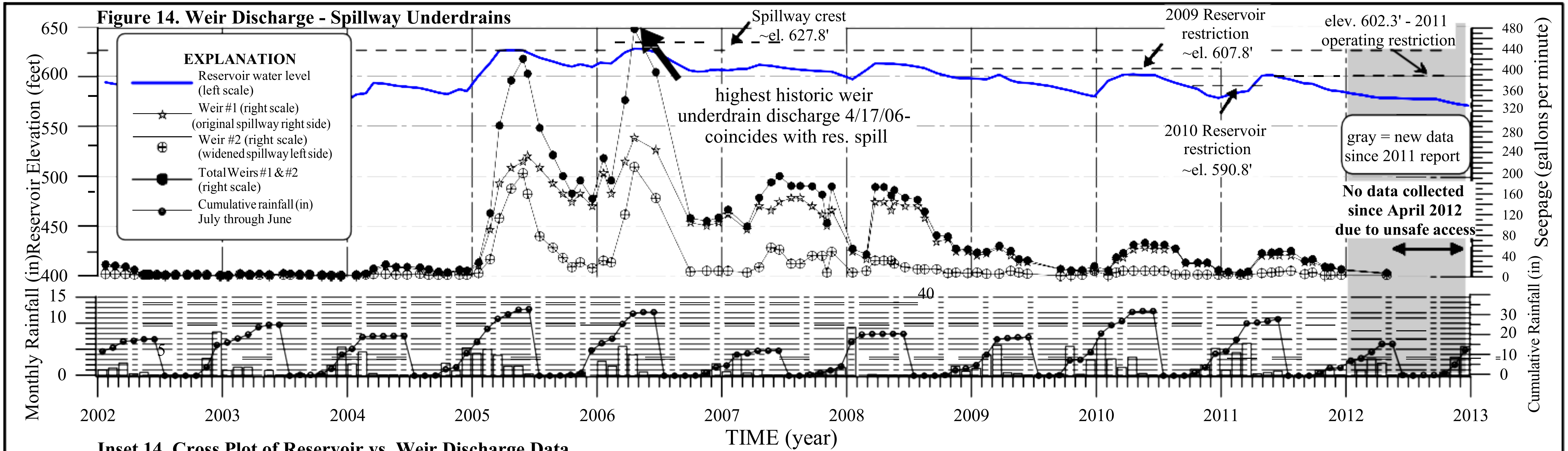
During 2012, the only combined flow readings from the weirs occurred in April 2012, with a value of ~5 gallons per minute (gpm). Flows are expected to be minimal because of the low reservoir levels during the current reporting period as discussed in *Section 4.5 Annual Reservoir Fluctuation.*

TABLE 3
Recent Weir Discharge Data – Spillway Underdrains
Leroy Anderson Dam

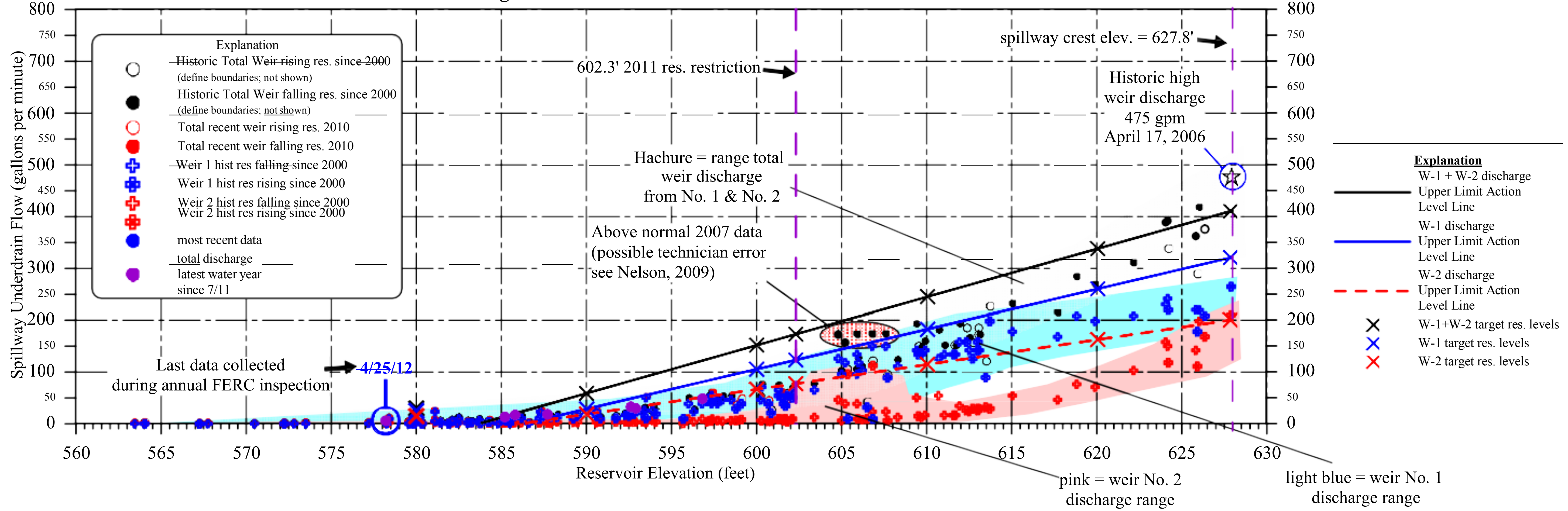
Date	Reservoir Level (ft)	Underdrain flow (gpm) Weir No. 1	Underdrain flow (gpm) Weir No. 2	Total flow (gpm)
12/14/2011	585.2	10.8	1.8	12.6
1/15/2012	582.8	NR	NR	NR
2/15/2012	581.3	NR	NR	NR
3/15/2012	579.3	NR	NR	NR
4/25/2012	578.8	3.6	1.8	5.4
5/15/2012	578.3	NR	NR	NR
6/15/2012	577.8	NR	NR	NR
7/12/2012	577.5	NR	NR	NR
8/15/2012	577.5	NR	NR	NR
9/19/2012	577.1	NR	NR	NR
10/16/2012	574.7	NR	NR	NR
11/19/2012	572.2	NR	NR	NR
12/19/2012	570.8	NR	NR	NR

Notes: 1) Weir No. 1 collects flow from the central portion of spillway
2) Weir No. 2 collects flow from the left side of the spillway
3) NR = not read due to unsafe access
4) W:\Geology\DAMS\Data\Pz\Anderson.xls

Figure 14. Weir Discharge - Spillway Underdrains



Inset 14. Cross Plot of Reservoir vs. Weir Discharge Data



Notes:

1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\piezo\Andweirtime&crossplts-12.grf

Santa Clara Valley Water District

Weir Discharge Data - Spillway Underdrains

Leroy Anderson Dam

FIGURE
14

To evaluate likely flows during the current period we looked at similar reservoir conditions when the levels were less than ~elev. 590 ft. during 2002 and 2004. During this earlier period the weir readings were essentially zero. Thus we can assume the readings during the current period would have likely been zero.

Action Levels for the underdrain discharge weirs are summarized on Table A3 in Appendix A. *Based on very limited data (2 data points), underdrain flow values are well below the upper Action Levels*.

4.7.2 Spillway Underdrain Flow Data Gaps

Underdrain flow data gaps of 7 to 8 months are present during the current reporting period significant with only one reading taken in April 2012 during the annual FERC inspection. No data was collected during the current period due to unsafe access issues. In November 2012 the District addressed safety issues for personnel collecting spillway weir readings by constructing a ladder to safely access the weirs. This will minimize future data gaps.

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4.8 Monument Surveys

4.8.1 Survey Procedures

Crest monuments were surveyed at the times indicated (typically once per year). Vertical survey data is collected and processed following the same methods used previously, traditional closed loop least squares adjusted leveling technique. Survey of monuments at Anderson Dam consists of using GPS techniques with data format in X-Y coordinates (eastings and northings, respectively). Offset (transverse) displacement data either upstream or downstream relative to the monument line established are calculated from the coordinate data using trigonometric relationships assuming stable reference points away from the dam and located in the right and left abutments. The reference baseline for the transverse displacement calculation uses the coordinates of the end points, assumed to be relatively stable monuments in bedrock immediately right and left of the dam, at the time the survey was first established.

During the period of this report, crest monuments (No. 16 through No. 30) and training wall monuments (No. 14 and No. 15) were monitored at the locations shown in Figure 1 (plan view) and in Figure 4 (longitudinal section view). After monument 31 was destroyed in ~2004, monument 30 was established as the left abutment control endpoint as the reference point to determine local transverse displacements.

Since July 1988 the District has used Global Positioning Satellite (GPS) methods to survey new crest monuments installed at Anderson Dam after the 1986-87 dam raise.

“Vertical” and “transverse” survey data collected since the December 2011 report (Nelson, 2011b) are shown as gray shading on Figures 15, 16 and 17.

4.8.2 Dam Crest and Abutment Monuments

The crest monuments generally alternate between the downstream edge and upstream edge of the crest. Data plots have been grouped as either “upstream (U/S) edge” or “downstream (D/S) edge”. The location of the surface monuments are shown in Figure 1 (plan view) and Figure 4 (longitudinal section view).

4.8.3 Survey Data – Dam Crest and Abutments

During the period of this report, dam crest monuments No.16 through No. 30 were monitored and their locations are shown on Figure 1. The vertical and transverse data for Anderson Dam is presented in Figures 15 and 16, and summarized on Table 4. Net vertical and transverse displacements since the last surveillance report (i.e. from October 2011 to the October 2012 survey) is shown at the bottom of each data set on Table 4.

Survey results of crest and abutment monuments indicate minimal horizontal and vertical displacements (less than 0.01 ft in the vertical plane and 0.02 in the horizontal plane) have occurred during this reporting period. These small displacements indicate that only minimal, normal displacements of the dam have occurred during this reporting period with no obvious trends.

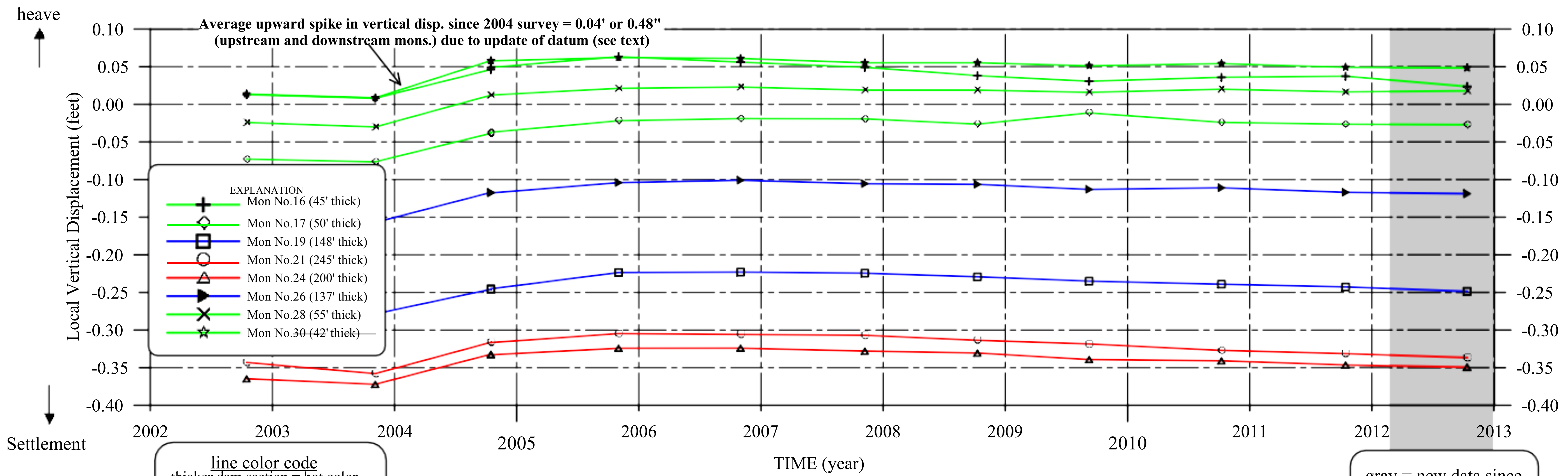

Figure 15a. Recent Local Vertical Displacements - Downstream Monuments

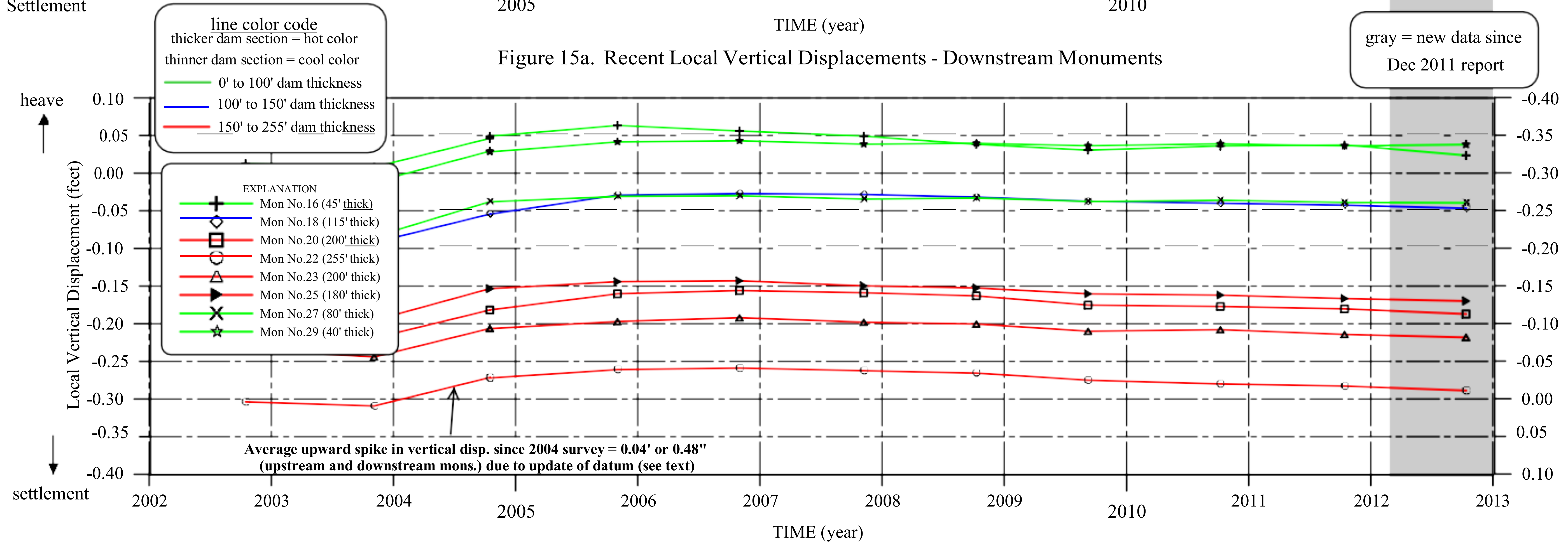

Figure 15b. Recent Local Vertical Displacements - Upstream Monuments

Notes:
1) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\survey\AndDS&USvertPlots-12.grf
2) Since the 2004 survey the District no longer shows changes in datums

Santa Clara Valley Water District

Recent Local Vertical Displacement
- Downstream and Upstream Crest Monuments
Leroy Anderson Dam

FIGURE
15

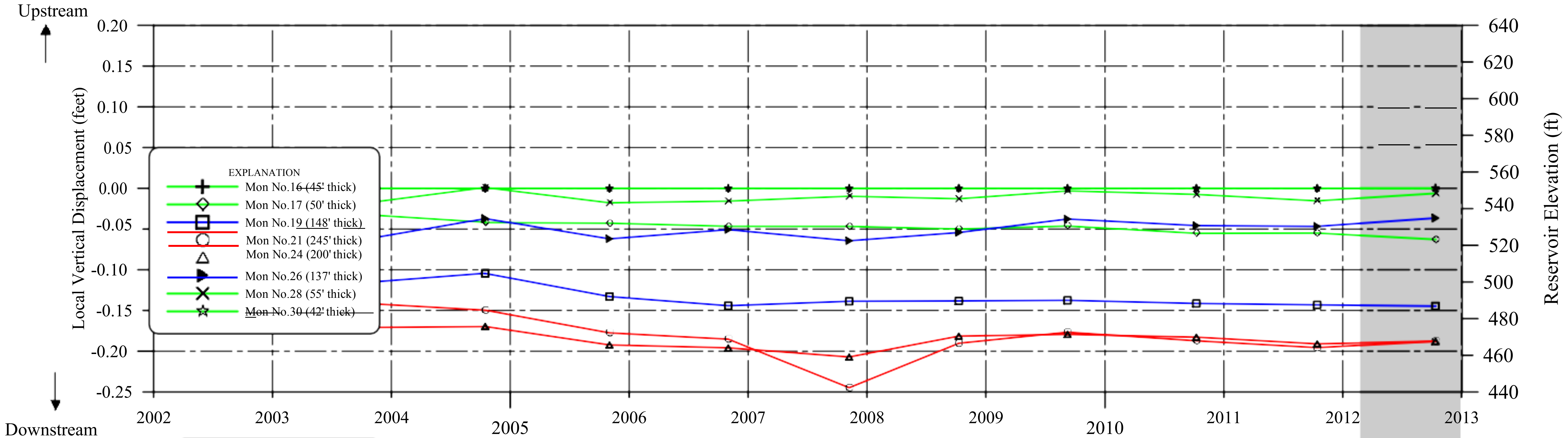

Figure 16a. Recent Local Transverse Displacements - Downstream Monuments

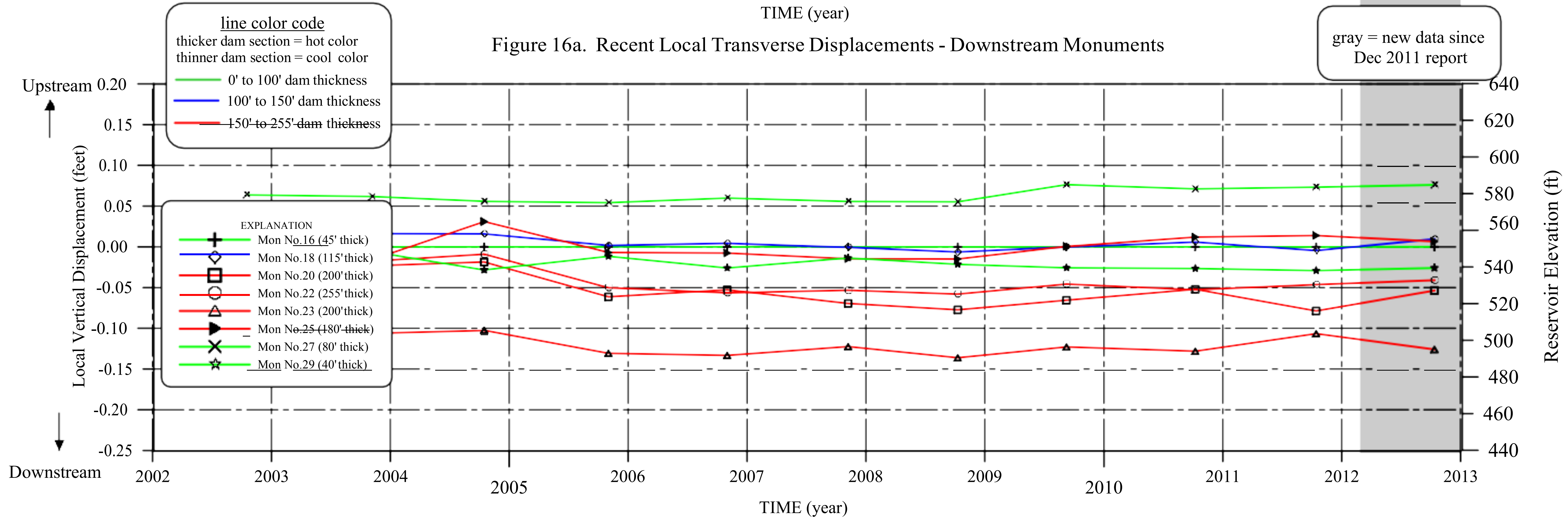

Figure 16b. Recent Local Transverse Displacements - Upstream Monuments

Notes:
1) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\survey\AndDS&UTransPlots-12.grf
2) Since the 2004 survey the District no longer shows changes in datums

Santa Clara Valley Water District

Recent Local Transverse Displacement
- Downstream and Upstream Crest Monuments
Leroy Anderson Dam

FIGURE
16

Action Levels for the survey monuments are summarized on Table A4 in Appendix A. _Crest monument movement values are well below the upper Action Levels. The values are also well above the lower Action Levels._

TABLE 4
Vertical and Local Transverse Data - Crest and Abutment Monuments
Leroy Anderson Dam

Date	Cumulative Monument Vertical Displacement (feet) (since 1988)														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10/14/2011	0.04	-0.03	-0.04	-0.24	-0.18	-0.33	-0.28	-0.21	-0.35	-0.17	-0.12	-0.04	0.02	0.04	0.05
10/12/2012	0.02	-0.03	-0.05	-0.25	-0.19	-0.34	-0.29	-0.22	-0.35	-0.17	-0.12	-0.04	0.02	0.04	0.05
change in disp.	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
10/10 to 10/11		Average change since last survey				=	-0.01 or 0.0"								

Date	Cumulative Dam Crest Monument Local Transverse Displacement (feet) (since 1988)														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10/14/2011	0.00	-0.05	0.00	-0.14	-0.08	-0.20	-0.05	-0.11	-0.19	0.01	-0.05	0.07	-0.02	-0.03	0.00
10/12/2012	0.00	-0.06	0.01	-0.14	-0.05	-0.19	-0.04	-0.13	-0.19	0.01	-0.04	0.08	-0.01	-0.03	0.00
change in disp.	0.00	-0.01	0.01	0.00	0.03	0.01	0.01	-0.02	0.00	-0.01	0.01	0.00	0.01	0.00	0.00
10/10 to 10/11		Average change since last survey				=	0.00	or 0.0"							

Notes:
1) Negative transverse displacement signifies downstream movement
2) Positive transverse displacement signifies upstream movement
3) Displacement is net displacement since 1988
4) NR = monument not surveyed (Mon. 31 destroyed during new boat ramp construction; Mon. 30 new control pt)
file:W:\Geology\DAMS\Annual Dam Safety Reports\Data\Survey\ANDsurvey.xls
5) Local Transverse data shown back calculated to 1988 - see text
6) Mons #16 and 30 are control points and do not show local transverse displacement

As shown in Figures 15 and 16, the time-series lines are color coded to generally depict the relative thickness of the embankment (depth from crest to foundation) directly beneath each monument on the vertical and transverse plots, where thicker dam sections are shown by hot colors and thinner sections are shown by cool colors. Red lines depict embankment thicknesses between ~150 feet and ~255 feet, blue is for embankment thicknesses between ~100 feet and 150 feet, and green is for embankment thicknesses between 0 feet and 100 feet. This gives a quick visual on whether monument movements are occurring on the more critical thicker sections relative to the less critical thinner sections of the dam.

The lines tend to group relative to color on Figures 15 and 16, with green lines (thinner section) generally plotting along the top, blue in the middle and red lines (thicker section) at the bottom of each plot. These trends indicate greater movements with time for thicker sections relative to thinner sections of the dam, which is typical for a large embankment dam with a significant differential in thicknesses. This appears to be generally true for both vertical and transverse displacements.

4.8.4 Monument Survey Data Gaps

There were no significant survey data gaps during the current reporting period.

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4.8.5 Spillway Training Wall Monuments

Three survey monuments are located at the top of the spillway training walls, two on a wall on the left side of the spillway ogee (Monument Nos. 14 and 15). Previous spillway training wall horizontal and vertical survey results may be questionable due to access issues. Because of the difficulty of accessing the monuments positioned at the bottom of a chain link fence, some errors may be introduced in the survey data from the spillway training walls (see Nelson and Volpe, 2004 for more information). Even with these limitations, this surveillance report provides historic data plots showing vertical displacement of Monuments 14 and 15 in Figure 17.

4.8.6 Survey Data – Training Wall

During the period of this report, Dam crest Monuments No.14 and No. 15 are monitored and their locations are shown on Figure 1. The vertical data for the training walls presented in Figure 17, and summarized on Table 5. Net vertical and transverse displacements since the last surveillance report (i.e. from October 2011 to October 2012) is shown at the bottom of each data set on Table 5.

Survey results of crest and abutment monuments indicate minimal horizontal and vertical displacements (less than 0.01 ft in the vertical plane) have occurred during this reporting period. These small displacements indicate that only minimal, normal displacements of the dam have occurred during this reporting period with no obvious trends.

Action Levels for the survey monuments are summarized on Table A4 in Appendix A. *Training wall monument movement values are well below the upper. Action Levels The values are also well above the lower Action Levels.*

TABLE 5
Vertical Displacement Data
Spillway Training Wall Monuments
Leroy Anderson Dam

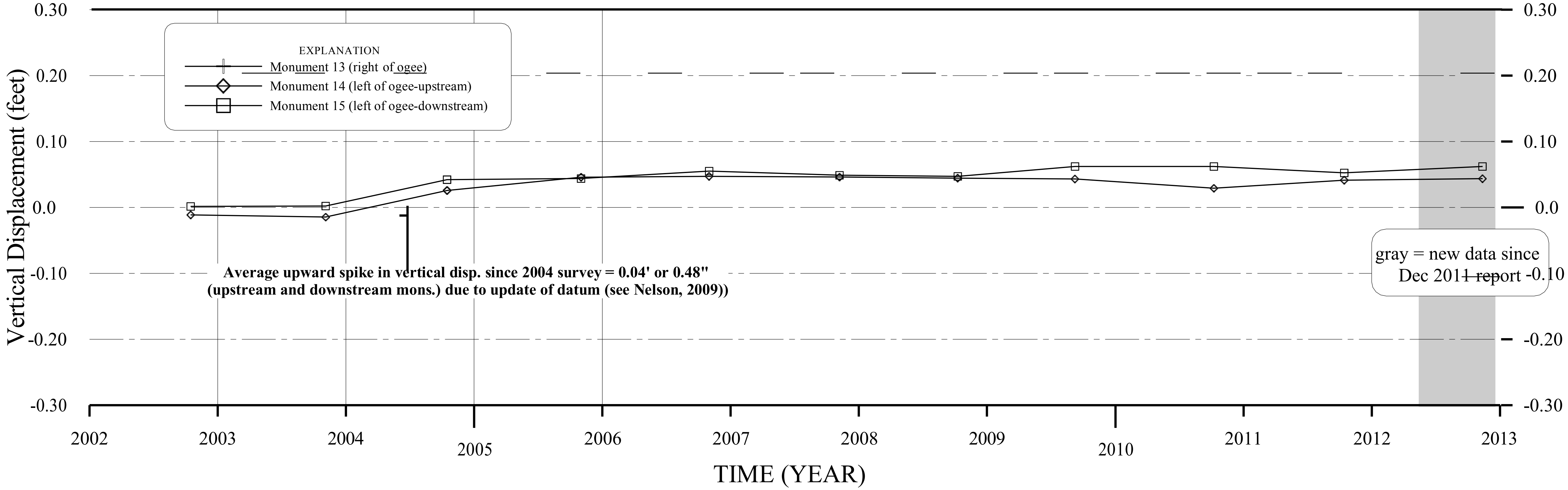
Date		Monument Vertical Displacement (feet)		
		13	14	15
10/14/2011		NR	0.04	0.05
10/12/2012		NR	0.04	0.06
change in disp. 10/11 to 10/12		NR	0.00	0.01

Avg. change since 10/11 = 0.01 or 0.12"

Notes:
1) Negative vertical displacement represents settlement
2) Positive vertical displacement represents heave
3) file:W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2012\survey\AndTranWallVert-12.xls

4.8.7 Spillway Training Wall Survey Data Gaps

There were no significant training wall survey data gaps during the current reporting period.



Average upward spike in vertical disp. since 2004 survey = 0.04' or 0.48"
(upstream and downstream mons.) due to update of datum (see Nelson, 2009))

gray = new data since
Dec 2011 report

Notes:
1) Mon. 13 not surveyed since October 2001
2) File W:\geology\annual dam safety reports\DSOD\Anderson\annual reports\2012\survey\AndtrainWVert-12.grf
3) Since the 2004 survey the District no longer shows changes in datums

Santa Clara Valley Water District

Vertical Displacements - Spillway Training Walls

Leroy Anderson Dam

FIGURE
17

4.9 In-Place Inclinometer Sensors (IPIs)

Six Little Dipper bi-axial sensors known as in-place inclinometer (IPIs) are located in inclinometer boring IPI9-1 (boring 72-9-ASI-1) shown on Table 6 and in Figure 1 (plan view) and Figures 3 and 4 (section view). The IPIs monitor gross internal movements of Leroy Anderson Dam related to significant earthquake or rapid drawdown of the reservoir. We differentiate between the individual in-place inclinometer boring (IPI) and in-place inclinometer Little Dipper bi-axial sensors (IPIs).

Since installation of the IPIs in September 2008, IPIs9-6 located at the bottom of the boring has provided erroneous data. On August 16, 2012 the District replaced the faulty sensor and has been collecting viable IPIs data since this date.

4.9.1 IPIs Data

Table 6 summarizes pertinent information on each IPIs including IPIs designation, drill hole designation, sensor depth, sensor elevation, and surface elevation at the top of the inclinometer boring.

Leroy Anderson Dam

Crest Inclinometer IPI9-1* (boring 72-9-AS1)

IPIs Designation	**X-axis & Y-axis**	Spacing between sensors (ft)	Sensor Depth (ft)	Sensor Elev. (ft)
IPIs9-1	9-1X	36.5	36.5	610.5
	9-1Y	"	"	"
IPIs9-2	9-2X	21.5	58	589.0
	9-2Y	"	"	"
IPIs9-3	9-3X	21.5	79.5	567.5
	9-3Y	"	"	"
IPsI9-4	9-4X	21.5	101	546.0
	9-4Y	"	"	"
IPIs9-5	9-5X	21.5	122.5	524.5
	9-5Y	"	"	"
IPIs9-6	9-6X	51.5	174	473.0
	9-6Y	"	"	"

notes:

1) * = formerly designated as IPI9-3

2) sensor spacing includes length of fiberglass connector rod and length of sensor

3) +Yaxis is pointing upstream and +X axis is pointing to the left abutment

4) Boring surface elevation = 647 ft (at crest)

5) green shading = IPIs9-6 replaced with functioning sensor 8/16/12

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4.9.2 In-Place Inclinometer Sensor Data

Due to the recent installation of a new sensor for IPIs9-6 and reinstallation of the remaining IPIs, the August 2012 installation date resulted in a reset of the data plots. Our review of the data after the reinstallation indicates the sensors are experiencing minor adjustments of the IPI sensors in response to stretching of the connecting rods due to gravity, which results in "apparent deflections" in the data plots that are not representative of actual movements of the dam. We decided that for the period of time that the sensors are experiencing adjustments we would not report this potentially erroneous data in our surveillance reports. Consequently, for the current period there are no IPIs data readings to report and no data plots of the IPIs.

4.9.3 IPIs Data Gaps

Because the IPIs are currently experiencing a period of adjustment in response to our installation of a new sensor in August 2012, and a reinstall of original IPIs (see *Section 4.9.2 In-Place Inclinometer Sensor Data*) we decided to not include IPIs data from August 2012 to the present. Consequently, a data gap exists roughly spanning ~5 months. Depending on when the sensors stabilize this data gap may extend for several more months into 2013. In the next surveillance report we will address new viable IPIs data once the stabilizing period is complete.

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4.10 U.S.G.S. and District Strong Motion Accelerometers

4.10.1 U. S. Geological Survey Accelerometers

Seven Kinematrics Model SMA-1 strong motion recorders (accelerometers) were installed in 1985 by the U.S. Geological Survey (U.S.G.S). Five accelerometers are installed on the downstream slope, one is situated about 150 feet south-southwest of the crest in the left abutment (see Figure 1), and one free field accelerometer is situated about 300 feet downstream of the toe of Anderson Dam. The accelerometers are operated and maintained by the U.S.G.S. District Dam Safety Program Unit personnel request seismic data from the U.S.G.S. if the seven instruments have recorded seismic accelerations after significant earthquakes occur in the vicinity of Anderson Dam.

During the current reporting period there are no accelerometer data to report.

4.10.2 District Accelerometer

An Altus Etna strong motion accelerometer manufactured by Kinemetrics is securely mounted on the floor of the blockhouse on the crest of the dam. The purpose of the accelerometer is to record accelerations in the vicinity of the dam in the event of an earthquake. The accelerometer continuously monitors ground acceleration and compares current acceleration levels to preset thresholds. When an excursion of the threshold acceleration value is detected, ADAS notifies the District with an alarm that the threshold condition (typically 0.03 g) was exceeded. No alarms were triggered during the period of this report.

ADAS is set up to query the accelerometer for possible data at a 10-minute frequency during every 24 hour period. In addition, ADAS routinely retrieves data from VWPs and IPIs every 10 minutes. These frequent-interval data are temporarily stored in flash cards in the ADAS instrumentation center located onsite in the block house on the crest of Anderson Dam. These data are only retrieved manually by District Dam Safety Program personnel after they have been alerted to an alarm condition of the accelerometer. Data flash cards are retrieved from the dam and taken back to the office, where all pertinent ADAS data recorded at 10-minute intervals are then compiled and analyzed.

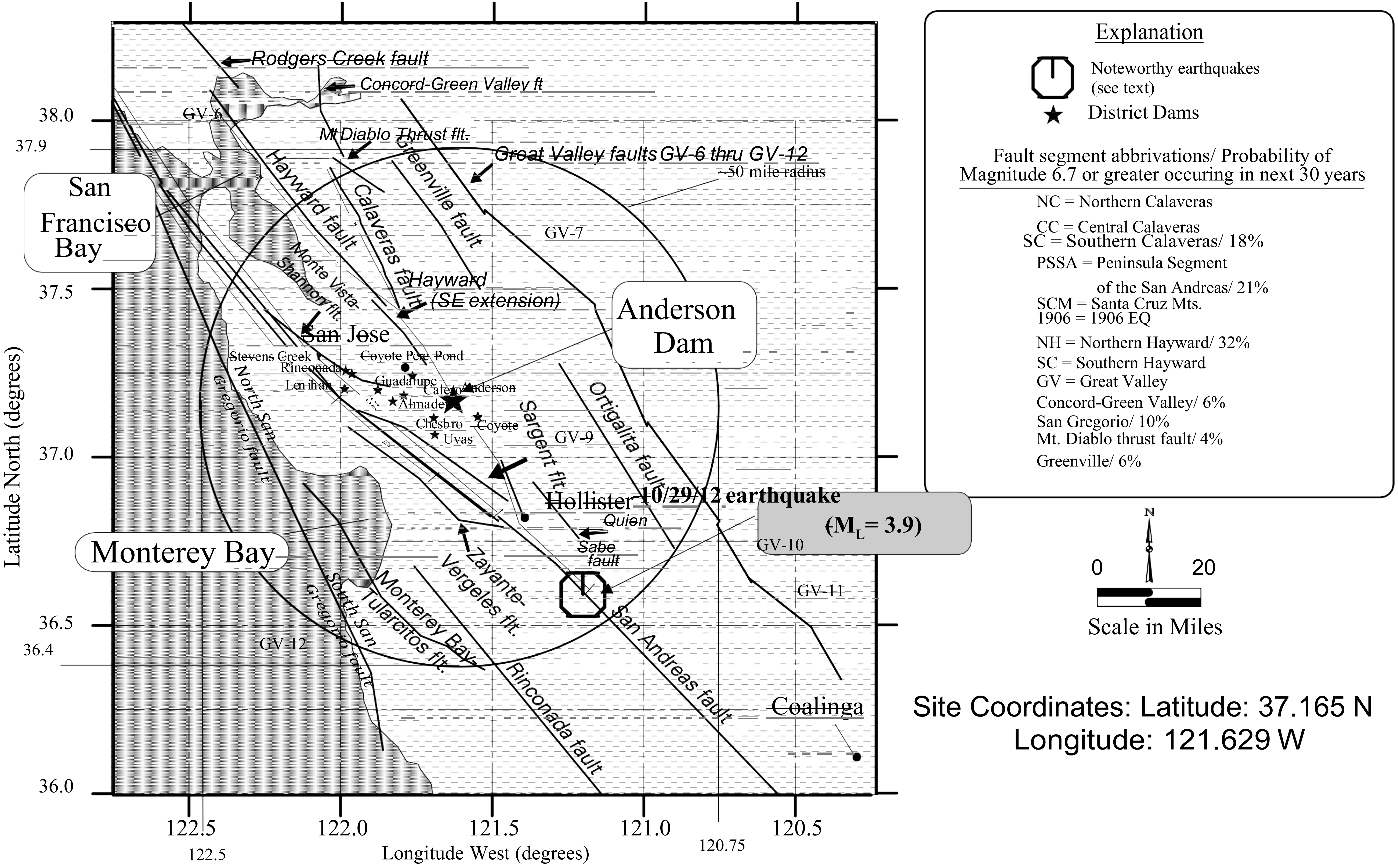
5.0 SIGNIFICANT AND NOTEWORTHY SEISMICITY

There were no earthquakes greater than M_L 5.0 during the reporting period from December 2011through December 2012 within 50 miles of Anderson Dam. Significant earthquakes are defined as having approximate magnitudes greater than M_L 5.0. Noteworthy earthquakes, defined as having approximate magnitudes less than M_L 5.0 but greater than about 4.0 occurring within 50 miles of the dam, occurred at one location in the San Francisco Bay Area, during the reporting period from December 2011 through December 2012 (Figure 18) with the following date, magnitude, distance and direction from Anderson Dam.

1. On October 29, 2012, M_L 3.9 earthquake, ~46 miles southeast

6.0 VISUAL INSPECTIONS AND MAINTENANCE ISSUES

The following significant inspections were performed during the period of this report include:



Site Coordinates: Latitude: 37.165 N
Longitude: 121.629 W

Notes: 1) File W:\geology\dams\annual dam safety reports\DSOD\Anderson\2012\seis\Andseis-12.grf

DATE	11/21/11
DESIGN	JLN
DRAWN	JLN
CHECKED	DEH

Santa Clara Valley Water District

Regional Fault Map Showing Noteworthy Earthquakes

Leroy Anderson Dam

SCALE 1"=20'

FIGURE 18

1. April 25, 2012, annual FERC inspection with District staff (H. Desai, R. Jacobs, M. Mooers, B. Baker, R. Ramento, R. Haskins, S. Wu, and J. Nelson), FERC Engineer E. Salire.
2. May 22, 2012, initial inspection of Anderson Dam and appurtenant facilities by the planning team for the Anderson Dam Seismic Retrofit Project (ADSRP) including several District employees.
3. June 28, 2012, inspection of Anderson Dam and appurtenant facilities by the planning team for the ADSRP including several District employees.
4. November 15, 2012, an informal site visit of Anderson Dam was performed after ADSRP BOC meeting #2 by FERC personnel G. Maloney, R. Finucane, E. Salire, D. Capka, W. Allerton, J. Mueller, and District personnel F. Maitski and J. Nelson.

6.1 Other District Inspections

This section presents additional safety inspection by District staff focused on maintenance and monitoring issues. It should be noted that Dam Safety Program maintenance administrator Ron Jacobs inspects Leroy Anderson Dam monthly.

1. February 13, 2012, B. Baker met with Roctest technician E. Constable to upgrade power packs including installation of new solar panel for the in-place inclinometer.
2. May 3, 2012, B. Baker and J. Nelson performed ADAS maintenance including battery replacement and functional test of the on-site accelerometer.
3. August 16, 2012, J. Nelson met on site with Eyasco personnel M. Estrada and J. Schuyler to install the replacement in-place inclinometer IPI9-6 (bottom sensor).
4. November 28, 2012, an informal site visit of Anderson Dam was performed by a Chinese delegation of 13 Engineers and District personnel H. Desai, J. Nelson, and M. Mooers.

7.0 SURVEILLANCE PROGRAM

For the period of December 2011 to December 2012, no significant modifications of the dam or appurtenant structures occurred that would impact the surveillance data or its interpretation.

The District will continue with the current operating procedures and scheduled surveillance plans. Pneumatic and open well piezometers will be read monthly, crest and spillway training wall monuments will be surveyed annually, and spillway underdrain flows will be measured at the two weirs at least monthly. ADAS instrumentation (vibrating wire piezometers) will be read daily. In-place inclinometer sensors (IPIs) readings were reset due to installation of a replacement IPIs in August 2012. In addition, site inspections and monument surveys will be conducted after a significant earthquake or other potentially disruptive activity.

To optimize DSOD and internal review of our surveillance reports we plan to make several changes involving data presentation in our next (2013) surveillance report. Specific details of these changes have not been formalized. This effort will likely involve concentrating on specific sensors/instruments deemed to be most critical to the monitoring of Anderson Dam.

The 2011 restriction will be in place until the seismic retrofit of the dam is completed, which is currently anticipated to be the end of 2018.

8.0 OTHER INFORMATION

8.1 Other Surveillance Items – Reservoir Level Verification and Valve Cycling

This section summarizes other routine surveillance items such as field verification of reservoir levels and valve cycling. District personnel make monthly visits to Anderson Reservoir to field check reservoir reference points relative to reservoir level readings measured by reservoir level sensors.

At Anderson Dam the upstream sluice gate valve was last cycled on May 15, 2012. Cycling of the values will be performed this winter when Anderson Reservoir level rises.

9.0 CONCLUSIONS

Anderson Reservoir is currently operating under a 2011 restriction to ~elev. 602.3ft, which is ~45 feet below the Dam crest.

The surveillance data from Anderson Dam and the District's field observations confirm acceptable performance of the dam for the period of this report, with the dam showing normal responses to the environment, aging process, and external events. There were no surveillance instrumentation alarm conditions.

On February 13, 2012, the District performed an upgrade of the power pack at the crest in-place inclinometers (IPIs) so that continuous power to the IPIs would result in viable data collection of sensor data by ADAS. Also, in August 2012 the District removed the bottom faulty IPI9-6 and installed a replacement sensor that is currently functioning properly.

In November 2012 the District addressed safety issues for personnel collecting spillway weir readings by constructing a ladder to safely access the weirs. This will minimize future data gaps.

Data gaps during the current monitoring period consisted of the following: ~4 months for VWP-8 due to power issues, ~8 months for the spillway underdrain due to unsafe access issues, and ~5 months for the IPIs due to post-installation adjustments of the IPI sensors in response to stretching of the connecting rods due to gravity.

The District will continue with the monitoring program and safety inspections, and will keep DSOD informed of any significant changes pertaining to the surveillance or performance of Leroy Anderson Dam. As mentioned above, the District plans to modify future surveillance reports to optimize the review process.

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Appendix A – Anderson Dam Instrumentation Action Levels

Tables A1 through A5

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  A1.3 Crest Monuments Surveys........1
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Table A2 – Equations for Piezometer Response and Action Levels - pneumatic, open well, and vibrating wire piezometers

Table A3 – Spillway Underdrain Discharge Response and Action Levels

Table A4 – Survey Crest Monument Summary Sheet and Action Levels

Table A5 – In-Place Inclinometer Sensors (IPIs) Data Sheet and Action Levels

A1.0 Instrumentation Action Levels

Appendix A summarizes developed Action Levels at Anderson Dam based on pertinent parameters.

Action Levels for the various surveillance instruments at Anderson Dam were developed by the District to aid in immediate field-verification of instrumentation readings and/or to assist in determining if readings are approaching a level which exceeds historic boundaries. If readings significantly exceed the Action Levels for a prolonged period, there could be concerns regarding the potential for instability or degradation of the embankment.

Specific Action Levels are summarized in Tables A1 through A5 for the respective instruments. Action Levels for pneumatic, open well, and vibrating wire piezometers are summarized on Tables A1 and A2. Spillway underdrain discharge weir Action levels are summarized on Table A3. Crest monuments Action Levels are summarized on Table A4. In-place inclinometer sensors (IPIs) action levels are summarized on Table A5. Figures 6 through 13 in the main text graphically show in cross plots the Upper Limit Action Levels (ULAL) and Lower Limit Action Levels (LLAL) for the piezometric surface of each piezometer and for the two discharge weirs (Figure 14).

A1.1 Open Well, Pneumatic, and Vibrating Wire Piezometers

Action Levels are based on Upper Limit Action Levels (ULAL) and Lower Limit Action Levels (LLAL). Specifically, Table A1 lists ULAL and LLAL values as Piezometric Surface Elevations (PSE) for each instrument tied to reference reservoir levels at 580 feet, 590 feet, 602.3 feet (2011 reservoir restriction elevation), 610 feet, 620 feet, and 627.8 feet (spillway lip elev.). Due to the 2011 reservoir restriction of 602.3 feet the higher target reservoir levels will not likely be reached. For convenience we chose these ~10-feet reference reservoir levels as representing the range of reservoir elevations during normal operations spanning the last 10 years. Also shown on Table A2 are equations for the trend lines that define the upper and lower limit Action Level lines. Upper and lower limit lines are shown on insets in Figures 6 through 13 for all piezometers.

A1.2 Spillway Underdrain Discharge (W-1 and W-2)

Table A3 summarizes spillway underdrain discharge response for weirs W-1 and W-2, along with Action Levels tied to reference reservoir levels at 580 feet, 590 feet, 602.3 feet (2011 reservoir restriction elevation), 610 feet, 620 feet, and 627.8 feet (spillway lip elev.). Also shown is the equation defining the ULAL. As shown by a cross plot of weir discharges in Inset 14, the data scatter occupies the entire lower portion of the plot so that a lower historic boundary is not meaningful. Consequently, we did not define a lower limit Action Level (LLAL) for the underdrain discharge data.

A1.3 Crest Monuments Surveys

As summarized on Table A4, the District decided to present Action Levels of ±0.05 feet of allowable change over a period of ~1 year for all northings, eastings, and Action Levels of ±0.05 feet of allowable changes in elevation values along the crest alignment. These Action Levels appear to adequately bracket possible ongoing "normal" deformation of Anderson Dam due to settlement and gravitational forces.

A1.4 In-Place Inclinometers

Table A6 summarizes Action Levels for IPIs based on historic response. The values are based on the historic maximum changes in amount of relative apparent instrument displacement recorded since the instruments were installed. We are not sure that the recorded displacements represent real deformation of the dam or are just “apparent data shifts”. It is highly likely that the recorded displacements to date are actually due to minor drift of the electronic sensor and not actual deformation.

A2.0 Methodology for Determining Action Levels

The main objective for determining Action Levels is to create applicable sensor specific upper (maximum) and lower (minimum) boundaries of surveillance data sets from individual instruments based on historical response of the sensor. Under normal conditions, instrument readings should be within historical ranges while under the same loading conditions. Typically, piezometers respond by exhibiting changes in piezometric surface elevations as reservoir elevations rise and fall. These changes may be obvious and somewhat predictable based on historic response trends. Similarly, weirs typically respond with changes in seepage discharge rates as reservoir elevations rise and fall. For piezometers and weirs that show significant response to changes in reservoir elevations, the piezometer and weir data excursions (upward and downward) should match or be attenuated relative to reservoir excursions. Surface monuments respond to gravitational/tectonic forces by moving vertically and horizontally.

While the main objective is to attempt to define Action Level limits that bracket all viable historic data, inevitably some data outliers are usually present. To determine suitable limits, we decided to disregard significant outliers from our analysis of Action Levels. It appears satisfactory to determine Action Level limits so that roughly 95% or more of the historic readings would remain within the established limits. It is therefore expected that periodic alerts will occur indicating that readings exceed the Action Levels. Such notifications are desirable and allow the Dam Safety Staff to validate that the notification system is working properly. It also allows the District to reset the Action Levels if necessary, especially if levels are significantly and routinely exceeded, but don’t represent an adverse condition. Dam Safety Staff responds to Action Level alerts according to District Quality and Environmental Management System (QEMS) (QSM-00000, 4/25/12). The following methodologies were used for each particular type of instrument.

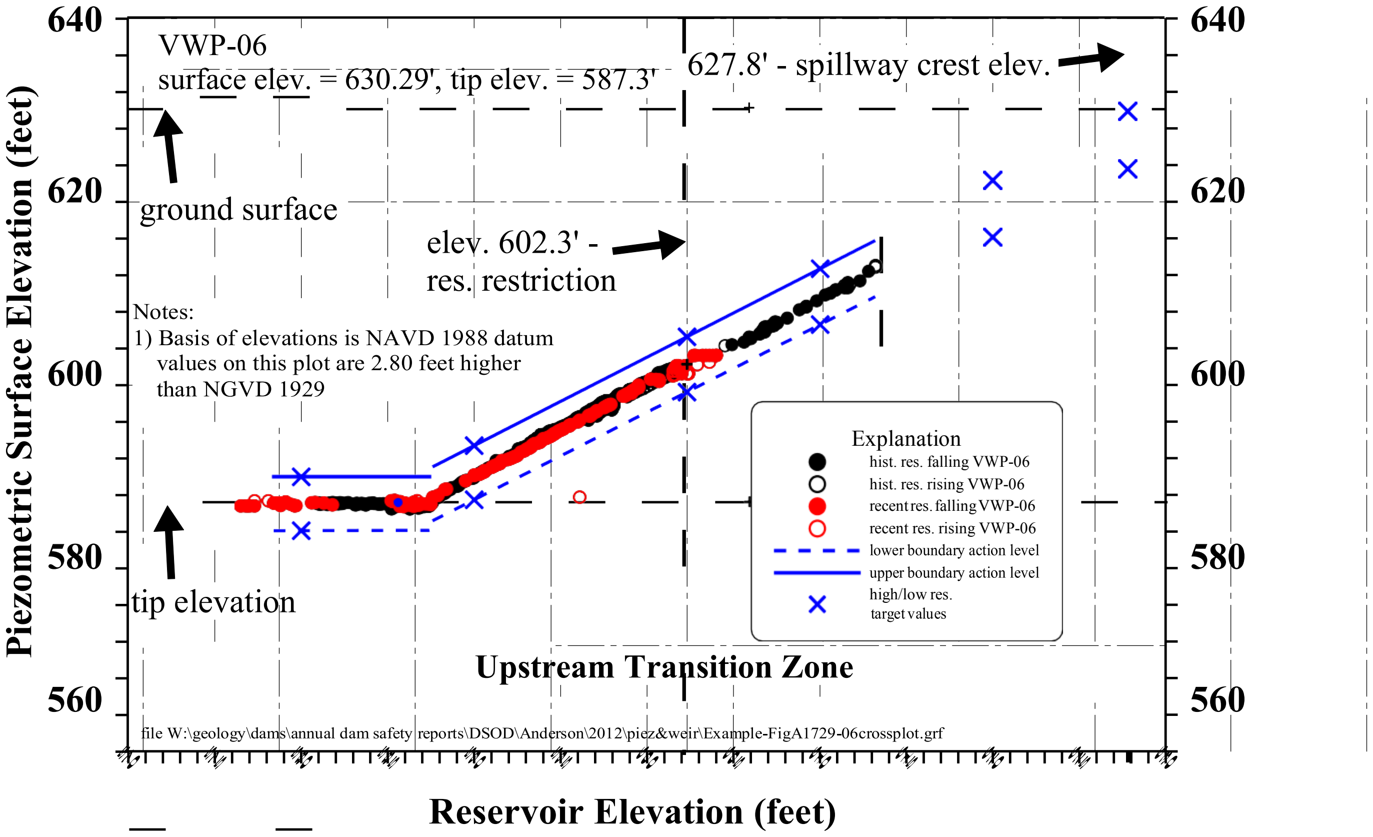
A2.1 Determining Piezometer and Discharge Weir Action Levels Using Cross Plots

One way to track the response trends for piezometers and weirs is to construct “cross plots” of reservoir elevations versus piezometric surface elevations (or seepage discharge rates for weirs). Plots shown as insets in Figures 6 through 13 are data cross plots for all piezometers. A plot shown as Inset 14 (Figure 14) is a cross plot of the two spillway underdrain discharge weirs.

The District typically uses cross plots as a tool for quality assurance/quality control to determine whether sensor data is reasonable and falls within historic trends. Cross plots are specifically useful for tracking historic trends independent of time but relative to reservoir response. Visually, the cross plots allow for quickly evaluating whether a given data point is reasonable, is out of the norm and therefore a sign of potential adverse conditions if higher than historic trends, or is possibly an outlier data point. As explained below, we also utilize the cross plot to establish Action Level limits for each instrument.

Figure A-1 is an example of how cross plots are used to determine instrument specific Action Levels. Specifically, Figure A-1 shows the response of VWP-6 located in the downstream foundation bedrock of

Anderson Dam and responds to changes in reservoir levels. A comparable plot is shown as Inset 13a, Figure 13. These cross plot show that as reservoir elevations increase there is a corresponding increase in the response of the piezometric surface elevation (PSE) of VWP-6. The plot of VWP-6 exhibits a fairly abrupt upward trend to the right; other plots have data trends that only have a slight slope upward to the right or plots that are essentially horizontal. Piezometer VWP-6 is also a special case where the cross plot (Figure A-1) shows a marked "dogleg", or a somewhat abrupt change. Additional limits are established for special cases such as VWP-6 as discussed below.



Notes:
1) Basis of elevations is NAVD 1988 datum values on this plot are 2.80 feet higher than NGVD 1929

Figure A-1. Example Action Level Based on Cross Plot of Reservoir Elevation vs. VWP-6 Piezometric Surface Elevation (PSE)

Instead of establishing Action Levels for a particular piezometer or weir solely based on historic maximum or minimum values, or upon "Engineering Design Basis Values", development of the levels should take into consideration the dynamic response of the instrument to its environment. For example, an Action Level for VWP-6, shown on Figure A-1, should account for the fact that at any particular reservoir elevation there are specific upper and lower limits to the possible readings of VWP-6. Action Levels for piezometers and weirs are therefore based on actual historic data response that are essentially dependent on the reservoir level at any given time. This approach provides a much more refined definition of Action Level values based on dynamic response as opposed to values based on relatively static historic maximum/minimum values.

The methodologies the District used to establish Action Levels for piezometers are based on simple graphic-analytical techniques for determining trend lines through historic data rather than rigorous statistical analysis.

The first step involves establishing trend lines through mathematically manipulated historic data set to determine boundary lines that generally follow the visually based boundary lines. The dark blue lines shown in Figure A-1 define upper and lower limit lines that are determined by fitting best-fit trend lines through actual historic piezometer values that have been manipulated mathematically depending on the historic response. For the example shown in Figure A-1, an upper limit trend line was developed through data by adding 0.5% of the piezometer value to each particular value. Likewise, the lower limit trend line was developed through data by subtracting 0.5% of the piezometer value from each value. The dark blue "Xs" on Figure A-1 lie along the Action Level limits at the reference reservoir levels 580 feet, 590 feet, 602.3 feet (2011 reservoir restriction elevation), 610 feet, 620 feet, and 627.8 feet (spillway lip elev.), as summarized for the original piezometers and the VWPs on Tables A1 and A2. For all Anderson Dam piezometer data, the Action Level limit lines typically fall within the range of ± 0.5% to ± 1.5% shown by the dark blue lines (Figure A-1; Insets in Figures 6 through 13 in main text).

Finally, suitable Action Levels are defined by the respective equation of the upper and lower dark blue trend lines of Figure A1. Specifically, equations for Upper Limit Action Levels (ULAL) and Lower Limit Action Levels (LLAL) are summarized for the original piezometers and VWPs on Table A1 and A2. Another way to assess Action Levels is to correlate upper limit and lower limit piezometer values with corresponding target reservoir levels. Table A-1 summarize Action Level ULAL and LLAL piezometer values tied to reference target reservoir levels chosen at convenient ~10-feet intervals to be 580 feet, 590 feet, 602.3 feet (2011 reservoir restriction elevation), 610 feet, 620 feet, and 627.8 feet (spillway lip elev.).

As indicated above, a further refinement of ULAL and LLAL boundaries was developed due to special piezometer cross plots that exhibit a "dogleg" (see Figure A-1) or abrupt change in the data trend line due to the dynamic response of the piezometer to reservoir changes over specific ranges of reservoir elevations. For these special cases where there is an abrupt change in data trend, we decided that more than one ULAL and/or LLAL may be needed to define the unique response behavior. If two ULAL trend lines were needed to define the upper limit, the higher ULAL for higher reservoir levels was designated with an "h" (ULALh) and the LLAL for lower reservoir levels was designated with an "l" (LLALl). Tables A-1 and A-2 shows these designated Action Level limits.

It is noteworthy that many piezometers exhibit relatively straight limit lines that define the upper and lower levels. Consequently, these piezometers have only one set of Action Levels designated as "h" (for high, i.e. ULALh and LLALh). There are only a few piezometers that possess two sets of limit lines defined by a bend, or dogleg. These cases are assigned both the first set (ULALh and LLALh) for the upper boundaries, and a second set of Action Levels designated as "l" (for low, i.e. ULALl and LLALl) for the lower limits.

A2.2 Spillway Underdrain Discharge Weirs (W-1 and W-2)

Cross plots of seepage response for the spillway underdrain discharge weirs are shown in Inset 14 (Figure 14). The method for determining Action Levels for the discharge weir was similar to those described above for piezometers. For example, an upper limit trend line was developed through the discharge data by adding 150% to each particular discharge value. Due to significant scatter, the weir data upper Action Level limit is typically much higher (150%) compared to piezometers (0.5% to 1.5%).

As shown by a cross plot of the respective discharge weir data in Inset 14, the data scatter occupies the entire lower portion of the plot so that a lower historic limit is not meaningful. Consequently, we did not define a Lower Limit Action Level (LLAL) for the discharge weir data.

A2.3 Crest Monument Surveys

As summarized in Table A4, Action Levels developed based on historic data and consist of > ±0.05 feet of resultant lateral displacements annually, and >±0.05 feet of vertical displacements annually.

A2.4 In-Place Inclinometer Sensors (IPIs)

As summarized in Table A5, Action Levels developed based on historic data and consist of > ±0.05 feet of resultant lateral displacements annually. It should be noted that the action levels apply only to incremental displacements.

A2.5 Reservoir Levels

No Action Levels are established for reservoir levels. However, monitoring of reservoir levels is integral to awareness of the response of the Anderson Dam to its environment as evident in potential changes in the phreatic surface through the dam (measured by piezometers) and changes in seepage (measured by seepage weirs) as reservoir levels fluctuate seasonally and in response to facility operations. It also adds to awareness of the ongoing safe operation of Anderson Reservoir. Dam safety awareness should be heightened, and could become critical, when reservoir levels reach spillway weir elevations as maximum static design loads are reached. Daily reservoir level readings at an accuracy of 0.1-foot appear to be suitable and are used for correlations with changes in the phreatic surface and seepage through the dam.

A2.6 Rainfall Data

No Action Levels are established for rainfall data. Monitoring rainfall in the Anderson Reservoir watershed is not a critical component of dam safety monitoring because rainfall does not by itself affect the performance of Anderson Dam. It is possible that some piezometric responses are related indirectly to rainfall, with rises in the phreatic surface in piezometers that are influenced by saturation of adjacent native ground. Rainfall does however, directly affect reservoir levels, especially during periods of prolonged and intense rainfall. Because of the overall affects on reservoir levels, there is an indirect affect on dam safety. Dam safety awareness should be heightened during prolonged periods of rainfall, because the reservoir has the capability to fill rapidly resulting in critical static loading of the dams. The most critical dam safety situation occurs when high reservoir levels (static loading) correspond with a significant earthquake (seismic loading). Daily rainfall totals at an accuracy of 0.1 in appear to be suitable and are used for correlation with changes in reservoir levels.

Table A1 - Piezometer Response and Action Levels Tied to Reservoir Elevations - Leroy Anderson Dam

Pneumatic and Open Well Piezometers, PPAs and OWs　Action Levels - See Text for Explanation
Vibrating Wire Piezometers, VWPs
602.3 = special Action Levels applicable to 2011 reservoir restriction (values used in Figures 2, 3, and 4)

Piezometer Number	PSE at Upper Limit Action Level (high) "ULALh"- 10 ft Res. Level Intervals						PSE at Lower Limit Action Level (high) "LLALh"- 10 ft Res. Level Intervals						PSE at Upper Limit Action Level (low) "ULALl"- 10 ft Res. Level Intervals						PSE at Lower Limit Action Level (low) "LLALl"- 10 ft Res. Level Intervals					
	Reference Reservoir Levels (feet)						Reference Reservoir Levels (feet)						Reference Reservoir Levels (feet)						Reference Reservoir Levels (feet)					
Original & OW Piezos	580	590	602.3	610	620	627.8	580	590	602.3	610	620	627.8	580	590	602.3	610	620	627.8	580	590	602.3	610	620	627.8
PPA-1	579.4	581.2	583.5	585.0	586.8	588.3	545.3	547.0	549.2	550.5	552.3	553.7	---	---	---	---	---	---	---	---	---	---	---	---
PPA-2	511.3	513.9	517.1	519.1	521.7	523.8	471.9	474.3	477.3	479.2	481.6	483.5	---	---	---	---	---	---	---	---	---	---	---	---
OW-1	408.1	408.0	408.0	408.0	408.0	408.0	404.0	404.0	404.0	403.9	403.9	403.9	---	---	---	---	---	---	---	---	---	---	---	---
OW-2	408.4	408.5	408.6	408.6	408.7	408.7	404.4	404.4	404.5	404.6	404.6	404.7	---	---	---	---	---	---	---	---	---	---	---	---
OW-3	413.8	413.8	413.9	413.9	414.0	414.0	409.6	409.7	409.8	409.8	409.9	409.9	---	---	---	---	---	---	---	---	---	---	---	---
Vibrating Wire Piezos													---	---	---	---	---	---	---	---	---	---	---	---
72-9-1/**VWP-1**	455.3	455.1	454.9	454.8	454.6	454.5	450.8	450.6	450.4	450.3	450.1	449.9	---	---	---	---	---	---	---	---	---	---	---	---
72-9-2/**VWP-2**	519.4	522.9	527.3	530.0	533.5	536.3	504.1	507.5	511.7	514.3	517.8	520.4	---	---	---	---	---	---	---	---	---	---	---	---
72-9-3/**VWP-3**	561.8	565.4	569.8	572.6	576.2	579.0	550.7	554.2	558.5	561.2	564.7	567.5	---	---	---	---	---	---	---	---	---	---	---	---
72-9-4/**VWP-4**	582.4	584.1	586.2	587.5	589.1	590.5	573.7	575.4	577.4	578.6	580.3	581.6	---	---	---	---	---	---	---	---	---	---	---	---
72-9-5/**VWP-5**	502.8	503.4	504.0	504.5	505.0	505.5	497.8	498.4	499.0	499.5	500.0	500.4	---	---	---	---	---	---	---	---	---	---	---	---
72-9-6/**VWP-6**	---	593.4	605.3	612.7	622.4	629.9	---	587.5	599.3	606.6	616.2	623.6	589.9	590.0	---	---	---	---	---	584.1	584.1	---	---	---
72-9-7/**VWP-7**	554.0	553.7	553.3	553.1	552.8	552.6	559.6	559.3	558.9	558.7	558.4	558.2	---	---	---	---	---	---	---	---	---	---	---	---
72-9-8/**VWP-8**	519.6	520.0	520.5	520.8	521.2	521.4	514.5	514.8	515.3	515.6	516.0	516.3	---	---	---	---	---	---	---	---	---	---	---	---
72-9-9B/**VWP-9B**	490.8	495.3	500.9	504.3	508.8	512.3	476.3	480.7	486.1	489.4	493.8	497.2	---	---	---	---	---	---	---	---	---	---	---	---
72-9-10/**VWP-10**	525.0	529.8	535.7	539.4	544.2	548.0	514.5	519.3	525.1	528.7	533.4	537.1	---	---	---	---	---	---	---	---	---	---	---	---
72-9-11/**VWP-11**	538.6	543.5	549.4	553.1	558.0	561.7	522.7	527.4	533.2	536.8	541.5	545.1	---	---	---	---	---	---	---	---	---	---	---	---
72-9-12/**VWP-12**	574.0	578.1	583.2	586.3	590.4	593.7	559.8	563.8	568.7	571.8	575.8	579.0	---	---	---	---	---	---	---	---	---	---	---	---
72-9-13/**VWP-13**	594.5	599.7	606.1	610.1	615.3	619.4	579.8	584.9	591.1	595.0	600.1	604.1	---	---	---	---	---	---	---	---	---	---	---	---
72-9-14/**VWP-14**	552.0	555.1	558.9	561.2	564.3	566.7	538.4	541.4	545.1	547.4	550.3	552.7	---	---	---	---	---	---	---	---	---	---	---	---
72-9-15/**VWP-15**	---	593.3	605.6	613.3	623.3	631.2	---	587.4	599.6	607.2	617.1	624.9	589.5	589.6	---	---	---	---	---	583.7	583.7	---	---	---
72-9-16/**VWP-16**	542.2	541.9	541.5	541.2	540.9	540.6	536.8	536.5	536.1	535.8	535.5	535.2	---	---	---	---	---	---	---	---	---	---	---	---
72-9-17/**VWP-17**	422.1	422.0	421.8	421.7	421.6	421.5	417.9	417.8	417.6	417.5	417.4	417.3	---	---	---	---	---	---	---	---	---	---	---	---
72-9-18/**VWP-18**	582.5	582.5	582.4	582.4	582.4	582.3	576.7	576.7	576.6	576.6	576.6	576.5	---	---	---	---	---	---	---	---	---	---	---	---
72-9-19/**VWP-19**	518.6	518.8	519.0	519.1	519.3	519.4	513.4	513.6	513.8	513.9	514.1	514.3	---	---	---	---	---	---	---	---	---	---	---	---
72-9-20/**VWP-20**	580.2	586.4	594.1	598.9	605.1	610.0	563.0	569.0	576.4	581.1	587.1	591.8	---	---	---	---	---	---	---	---	---	---	---	---
72-9-21/**VWP-21**	453.5	453.8	454.1	454.3	454.6	454.9	449.0	449.2	449.6	449.8	450.1	450.3	---	---	---	---	---	---	---	---	---	---	---	---
72-9-22/**VWP-22**	527.1	530.7	535.1	537.8	541.4	544.2	514.0	517.5	521.8	524.5	528.0	530.7	---	---	---	---	---	---	---	---	---	---	---	---
72-9-23/**VWP-23**	556.6	561.4	567.3	571.0	575.8	579.6	542.8	547.5	553.3	556.9	561.6	565.2	---	---	---	---	---	---	---	---	---	---	---	---
72-9-24/**VWP-24**	572.3	576.0	580.5	583.4	587.0	589.9	558.1	561.7	566.1	568.9	572.5	575.3	---	---	---	---	---	---	---	---	---	---	---	---
72-9-25/**VWP-25**	546.6	551.4	557.3	561.0	565.9	569.6	557.7	562.6	568.7	572.4	577.4	581.2	---	---	---	---	---	---	---	---	---	---	---	---
72-9-26/**VWP-26**	584.9	588.6	593.1	596.0	599.6	602.5	570.4	574.0	578.4	581.2	584.8	587.6	---	---	---	---	---	---	---	---	---	---	---	---
72-9-27/**VWP-27**	---	590.4	600.3	606.4	614.4	620.7	---	584.5	594.3	600.4	608.3	614.5	587.5	587.6	---	---	---	---	---	581.7	581.8	---	---	---
72-9-28/**VWP-28**	413.9	413.8	413.7	413.6	413.5	413.4	407.7	407.6	407.5	407.5	407.4	407.3	---	---	---	---	---	---	---	---	---	---	---	---
72-9-29/**VWP-29**	478.5	477.8	476.9	476.3	475.6	475.0	473.8	473.0	472.1	471.6	470.8	470.2	---	---	---	---	---	---	---	---	---	---	---	---
72-9-30/**VWP-30**	496.8	498.6	500.7	502.0	503.8	505.1	487.0	488.7	490.8	492.1	493.8	495.1	---	---	---	---	---	---	---	---	---	---	---	---
72-9-31/**VWP-31**	605.0	605.3	605.6	605.8	606.1	606.3	598.9	599.2	599.6	599.8	600.1	600.3	---	---	---	---	---	---	---	---	---	---	---	---

Notes:

1) Action Levels are based on piezometer values tied to upper boundary action level (ULALh & ULALl) and lower boundary action level (LLALh & LLALl), corresponding with target reservoir levels for the respective instrument.

2) Upper boundary and Lower boundary action level piezometer values are tied to reference target reservoir levels chosen at convenient ~10-feet intervals to be 580 feet, 590, 602.3 feet (2011 res. restriction), 610 feet, 620 feet, and 627.8 feet (spillway elev.).

3) "h" for "high" and "l" for "low" are based on special piezometer cross plots where an abrupt change, i.e. “dogleg” correlates with a change in the data trend line over specific ranges of reservoir elevations.
For plots defined by two upper boundary and two lower boundary trend lines, the higher designation “h” for two high reservoir level boundaries (i.e. ULALh and LLALh)
and lower designation “l” for two low reservoir level boundariess (i.e. ULALl and LLALl).

4) --- = not applicable

5) updated 12/17/12

Table A2 - Equations for Piezometer Response and Action Levels - Leroy Anderson Dam

Pneumatic and Open Well Piezometers, PPAs and OWs
Vibrating Wire Piezometers, VWPs

Action Levels - See Text for Explanation
where X = reservoir elev., Y = PSE

Piezometer Number	Upper Limit Action Level (high) "ULALh"	Lower Limit Action Level (high) "LLALh"	Upper Limit Action Level (low) "ULALl"	Lower Limit Action Level (low) "LLALl"
Original & OW Piezos	Equation for trend line through action levels % greater (+%) or % less than (-%) historic data	Equation for trend line through action levels % greater (+%) or % less than (-%) historic data	Equation for trend line through action levels % greater (+%) or % less than (-%) historic data	Equation for trend line through action levels % greater (+%) or % less than (-%) historic data
PPA-1	Y = 0.186546717 * X + 471.1577701 @ +2.0%	Y = 0.1755733807 * X + 443.4426071 @ -4.0%	--- --- --- --- ---	--- --- --- --- ---
PPA-2	Y = 0.2616639334 * X + 359.4946154 @ +4.0%	Y = 0.2415359385 * X + 331.8411834 @ -4.0%	--- --- --- --- ---	--- --- --- --- ---
OW-1	Y = -0.001592671167 * X + 408.9804836 @ +0.5%	Y = -0.001576823693 * X + 404.911026 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
OW-2	Y = 0.006109970947 * X + 404.8996192 @ +0.5%	Y = 0.006049175216 * X + 400.8707673 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
OW-3	Y = 0.00599351822 * X + 410.2801722 @ +0.5%	Y = 0.005933881223 * X + 406.1977824 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
Vibrating Wire Piezos				
72-9-1/**VWP-1**	Y = -0.01815712156 * X + 465.8558809 @ +0.5%	Y = -0.01797645368 * X + 461.220499 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-2/**VWP-2**	Y = 0.3528880316 * X + 314.7455991 @ +1.5%	Y = 0.3424578435 * X + 305.4427735 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-3/**VWP-3**	Y = 0.3590471452 * X + 353.5849021 @ +0.5%	Y = 0.3519019284 * X + 346.5483866 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-4/**VWP-4**	Y = 0.1684563985 * X + 484.694834 @ +0.5%	Y = 0.1635915983 * X + 478.8530195 @ -1.0%	--- --- --- --- ---	--- --- --- --- ---
72-9-5/**VWP-5**	Y = 0.05543658562 * X + 470.6571664 @ +0.5%	Y = 0.05488497781 * X + 465.9740105 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-6/**VWP-6**	Y = 0.9655530979 * X + 23.72552967 @ +0.5%	Y = 0.9559456044 * X + 23.48945474 @ -0.5%	Y = -0.005699786691 * X + 593.3834549 @ +0.5%	Y = -0.005643072395 * X + 587.4791419 @ -0.5%
72-9-7/**VWP-7**	Y = -0.02901948113 * X + 570.8246225 @ +0.5%	Y = -0.0293111342 * X + 576.5615534 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-8/**VWP-8**	Y = 0.03782187994 * X + 497.7014307 @ +0.5%	Y = 0.03744554283 * X + 492.7491777 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-9B/**VWP-9B**	Y = 0.4497307659 * X + 229.9885203 @ +1.5%	Y = 0.4364382309 * X + 223.1908301 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-10/**VWP-10**	Y = 0.4811101148 * X + 245.9505071 @ +0.5%	Y = 0.4715357842 * X + 241.0559696 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-11/**VWP-11**	Y = 0.4831662749 * X + 258.404549 @ +1.5%	Y = 0.4688854983 * X + 250.7669761 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-12/**VWP-12**	Y = 0.411210215 * X + 335.4942457 @ +1.0%	Y = 0.4010317443 * X + 327.1899327 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-13/**VWP-13**	Y = 0.5207928816 * X + 292.4307727 @ +1.0%	Y = 0.5079019687 * X + 285.1923873 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-14/**VWP-14**	Y = 0.3067303215 * X + 374.1413549 @ +1.0%	Y = 0.2991379868 * X + 364.8804303 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-15/**VWP-15**	Y = 1.001992235 * X + 2.114322353 @ +0.5%	Y = 0.9920221635 * X + 2.09328432 @ -0.5%	Y = 0.004353830356 * X + 587.0662036 @ +0.5%	Y = 0.004310508661 * X + 581.2247489 @ -0.5%
72-9-16/**VWP-16**	Y = -0.03384973057 * X + 561.8620016 @ +0.5%	Y = -0.03351291733 * X + 556.2713349 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-17/**VWP-17**	Y = -0.01329471785 * X + 429.7971612 @ +0.5%	Y = -0.0131624321 * X + 425.5205725 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-18/**VWP-18**	Y =-0.00418619838 * X + 584.946374 @ +0.5%	Y = -0.004144544665 * X + 579.126012 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-19/**VWP-19**	Y = 0.01768742392 * X + 508.3196574 @ +0.5%	Y = 0.01751142965 * X + 503.2617504 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-20/**VWP-20**	Y = 0.6224819259 * X + 219.1620131 @ +0.5%	Y = 0.6039923637 * X + 212.6522503 @ -2.0%	--- --- --- --- ---	--- --- --- --- ---
72-9-21/**VWP-21**	Y = 0.02935873024 * X + 436.4341617 @ +0.5%	Y = 0.02906660357 * X + 432.0915333 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-22/**VWP-22**	Y = 0.3584113447 * X + 319.1932215 @ +1.0%	Y = 0.3495397768 * X + 311.2923992 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-23/**VWP-23**	Y = 0.4813535071 * X + 277.3929632 @ +1.0%	Y =0.4694388163 * X + 270.5268007 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-24/**VWP-24**	Y = 0.369109799 * X + 358.2018482 @ +1.0%	Y = 0.3599734178 * X + 349.3354658 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-25/**VWP-25**	Y = 0.4819664845 * X + 267.0452347 @ +0.5%	Y = 0.491752606 * X + 272.4674729 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-26/**VWP-26**	Y = 0.368848663 * X + 370.9555184 @ +1.0%	Y =0.3597187456 * X + 361.7734511 @ -1.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-27/**VWP-27**	Y = 0.8015003458 * X + 117.5105204 @ +0.5%	Y = 0.793525218 * X + 116.3412614 @ -0.5%	Y = 0.01026885026 * X + 581.6857081 @ +0.5%	Y = 0.01016667264 * X + 575.8977906 @ -0.5%
72-9-28/**VWP-28**	Y = -0.009497377729 * X + 419.3915294 @ +1.0%	Y = -0.009356327565 * X + 413.1629423 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-29/**VWP-29**	Y = -0.07435357319 * X + 521.6495765 @ +1.0%	Y = -0.07361373664 * X + 516.4590334 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---
72-9-30/**VWP-30**	Y = 0.1740089912 * X + 395.8941721 @ +1.0%	Y = 0.1705632686 * X + 388.0546836 @ -1.0%	--- --- --- --- ---	--- --- --- --- ---
72-9-31/**VWP-31**	Y = 0.02900854172 * X + 588.1364997 @ +0.5%	Y = 0.02871989952 * X + 582.2843953 @ -0.5%	--- --- --- --- ---	--- --- --- --- ---

Notes:

1) Action Levels are based on piezometer values tied to upper limit action level (ULALh & ULALl) and lower limit action level (LLALh & LLALl), corresponding with target reservoir levels for the respective instrument.

2) Upper boundary and Lower boundary action level piezometer values are tied to reference target reservoir levels chosen at convenient ~10-feet intervals to be 580 feet, 590, 602.3 feet (2011 res. restriction), 610 feet, 620 feet, and 627.8 feet (spillway elev.).

3) "h" for "high" and "l" for "low" are based on special piezometer cross plots where an abrupt change, i.e. “dogleg” correlates with a change in the data trend line over specific ranges of reservoir elevations.

For plots defined by two upper boundary and two lower boundary trend lines, the higher designation “h” for two high reservoir level boundaries (i.e. ULALh and LLALh)
and lower designation “l” for two low reservoir level boundariess (i.e. ULALl and LLALl).

4) --- = not applicable

5) updated 12/17/12

Table A3 - Spillway Underdrain Discharge Response and Action Levels - Leroy Anderson Dam

Spillway Underdrain Discharge Weirs W-1 and W-2
Action Levels - See Text for Explanation

Discharge flow in gallons per minute (gpm) relative to reservoir elevations

Weir Number	Upper Limit Action Level (high) "ULALh"- 10 ft Res. Level Intervals						
	Reference Reservoir Levels (feet)						
	580	590	602.3	610	620	627.8	Lower Limit Action Level
W-1 (gpm)	25	28	123	182	259	319	Not applicable - see text
W-2 (gpm)	15	18	77	114	162	199	ditto
W-1 + W-2 (gpm)	30	58	172	244	337	409	ditto

Equation of action level trend lines

Weir Number	Upper Limit Action Level high "ULALh" where X = reservoir elev., Y = discharge in gpm	
	historic data % greater (+%) or % less than (-%) Equation for trend line through action levels	Lower Limit Action Level
W-1	Y = 7.700326801 * X - 4515.131907 @ +50%	Not applicable - see text
W-2	Y = 4.800890761 * X - 2814.507838 @ +150%	ditto
W-1 + W-2	Y = 9.28087106 * X - 5417.40232 @ +50%	ditto

Note: gpm = gallons per minute
602.3 = special Action Levels applicable to 2011 reservoir restriction

Table A4 - Survey Monument Data Sheet and Action Levels

Leroy Anderson Dam

Initial Terrestrial Survey on July 19, 1988					**Action**	**Levels**	
Wing Wall Monuments installed 1988							
Mon. Number	**Location**	**Northing (ft)**	**Easting (ft)**	**Elev. (ft)**	**Delta Northing (ft)**	**Delta Easting (ft)**	**Delta Elev. (ft)**
13	brass disk top of North wing wall	1885740.1	6232557.6	647.4	± 0.05	± 0.05	± 0.05
14	brass disk top of South wing wall	1885417.1	6232506.9	647.4	± 0.05	± 0.05	± 0.05
15	brass disk top of South wing wall	1885463.7	6232412.3	647.4	± 0.05	± 0.05	± 0.05
					Action	**Levels**	
New Crest Monuments installed 1988 (original monuments no longer monitored)							
16	right abutment -	1885310.9	6232275.6	645.4	± 0.05	± 0.05	± 0.05
17	crest - downstream	1885253.5	6232286.4	646.4	± 0.05	± 0.05	± 0.05
18	crest - upstream	1885179.7	6232348.4	646.4	± 0.05	± 0.05	± 0.05
19	crest - downstream	1885086.4	6232370.2	646.8	± 0.05	± 0.05	± 0.05
20	crest - upstream	1885007.1	6232435.6	646.2	± 0.05	± 0.05	± 0.05
21	crest - downstream	1884891.0	6232469.0	646.6	± 0.05	± 0.05	± 0.05
22	crest - upstream	1884755.6	6232561.9	646.4	± 0.05	± 0.05	± 0.05
23	crest - centerline	1884642.0	6232613.1	646.5	+ 0.05	+ 0.05	+ 0.05
24	crest - downstream	1884613.9	6232615.6	646.8	+ 0.05	+ 0.05	+ 0.05
25	crest - upstream	1884568.5	6232701.9	646.4	+ 0.05	+ 0.05	+ 0.05
26	crest - downstream	1884474.6	6232777.2	646.8	+ 0.05	+ 0.05	+ 0.05
27	crest - upstream	1884396.3	6232900.8	646.4	+ 0.05	+ 0.05	+ 0.05
28	crest - downstream	1884314.0	6232962.6	646.8	+ 0.05	+ 0.05	+ 0.05
29	crest - upstream	1884289.5	6233023.4	646.4	+ 0.05	+ 0.05	+ 0.05
30	crest - centerline	1884280.4	6233015.7	646.6	+ 0.05	+ 0.05	+ 0.05
31	left abutment - destroyed	1884210.3	6233093.5	646.4	+ 0.05	+ 0.05	+ 0.05

Notes:

1) Mons #16 and 30 are control points

2) Mon. 31 former control points destroyed during new boat ramp construction

Table A5 - In-Place Inclinometer Sensors (IPIs) Data Sheet and Action Levels

Leroy Anderson Dam

Boring 72-9-ASI-1 or 19a (IPI9-3-1)		Crest
northings	eastings	ground elev.
1884827.94	6232521.5	647

Instrument Designation	X-axis and Y-axis directions	Length (L) between Sensors (in)	Sensor depth (ft)	Sensor Elev. (ft)	Sensor Serial No.	Instrument Angular Range	Scale Factor (SF) (arc°/V)	Action Levels (ft)
IPI9-3-1	9-3-1X	35	35	612	3259	±12.5°	4.240	±0.05
	9-3-1Y						4.221	±0.05
IPI9-3-2	9-3-2X	20	55	592	3260	±12.5°	4.148	±0.05
	9-3-2Y						4.133	±0.05
IPI9-3-3	9-3-3X	20	75	572	3261	±12.5°	4.089	±0.05
	9-3-3Y						4.078	±0.05
IPI9-3-4	9-3-4X	20	95	552	3262	±12.5°	4.309	±0.05
	9-3-4Y						4.315	±0.05
IPI9-3-5	9-3-5X	20	115	532	3263	±12.5°	4.167	±0.05
	9-3-5Y						4.169	±0.05
IPI9-3-6!	9-3-6X	50	165	482	3264	±12.5°	4.217	±0.05
	9-3-6Y						4.218	±0.05

Notes
1) IPI Model 906V-H - Little Dipper, Bipolar Output, Vertical Orientation
2) IPIs manufactured by Applied Geomechanics, Inc. Santa Cruz, CA
3) Equation to convert sensor readout in volts (N) to lateral displacement (in)
where D = L*sin(N*SF)
where N = volts,
D = lateral disp. ft,
L = length between senors
4) Biaxial Tiltmeters measure tilt along two axis: X and Y
5) sensor spacing includes length of fiberglass connector rod and length of sensor
6) * = action levels tied to incremental displacement only, does not apply to cumulative displacement
7) ! = new replacement sensor installed 8/16/12